# Project Completion Report

## Criteria and Methodology for Assessing the Environmental-Aesthetic-Social-Economic Impact of Sand Mining on Barrier Dunes in Michigan.

Open-File Report MGSD OFR 78 - 5 1978

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## Preface

This research effort was initiated in response to a request for assistance from personnel of the Geological Survey Division of the Michigan Department of Natural Resources. It falls in the category of heuristic research by virtue of the fact that supporting background research on the topic is extremely limited and only residual funds and limited time were available to address the primary research objective. Work began in January 1973 and continued for a moderate period beyond the September 15, 1978 completion target date to assemble the best available information. To accomplish the research objectives grant funds were augmented with Michigan State University Experiment Station funds and Affirmative Action Assistantship funds.

Research for this project was conducted under the direction of Dr. Ronald L. Shelton and Dr. Eckhart Dersch by Bradley 0. Parks, Beverly Fleischer, John J. Kornacki and Jay P. Derr.

The project directors are most appreciative of the cooperation and assistance provided by R. Thomas Segall , Jon Roethele and Michael Chapman of the Michigan Department of Natural Resources, Geological Survey Division. In addition valuable background information and useful suggestions were generously provided by Dr. William M. Marsh, University of Michigan - Flint, and Dr. Erwin Seibel, University of Michigan, Ann Arbor.

## Summary

This research was designed to identify the best available information for describing and measuring the impacts of barrier dunes (as defined by the Michigan Department of Natural Resources) within Michigan's Great Lakes sand dune areas on aesthetic, environmental, economic, industrial and agricultural interests. From this information was derived an appropriate set of impact criteria and a rational system for applying these criteria to the analysis of specific barrier dune sites. The ultimate application of this information will be to evaluate and predict the probable impact of a proposed sand dune mining operation regulated under Act 222 of 1976, The Michigan Sand Dune Protection and Management Act.

Early sections of the report detail the potential impact-causing attributes of sand dune mining as well as the basic concepts and criteria used for measuring impact. The report presents the conceptual base for more precise

assessment and suggests that quantitative measurement is possible. Unlike impact criteria used to quantify the lethal dose of toxic substances, sand dune mining impacts tend to be more subjective than objective given the present state-of-the-art. Furthermore, it was determined that the impact on defined interests could most systematically and effectively be described in terms of aesthetic, physical-biological, and socio-economic impacts.

Recognizing then, that description will dominate methodology and that detailed professional surveys for aesthetic, socio-economic and biological analysis are not likely to be conducted on each proposed mining site, the focus of this study was to extract from concepts and theory those criteria that could be part of each sand mining impact assessment. These criteria were organized into checklists that would be matched with impact-causing activities of sand mining operations. This combination of criteria and mining activities is illustrated by an abbreviated form of a potentially elaborate matrix.

It is suggested that each sand mining applicant descriptively address all appropriate interactive points on the matrix derived from on-site observations. From this a reasonable estimate can be made of the quantitative and/or qualitative impacts on such factors as adjacent land uses, biological resources including endangered and threatened species, ground water supply and adjacent surface resources. An informal site review was conducted and it was concluded that this process for impact assessment would suffice for the present time.

Evaluation of the impact assessments prepared by sand mining applicants should undergo extensive interagency review. Due to the subjective and qualitative nature of such impact assessments and the locally and regionally significant effect of sand mining activities the public and local units of government must also be an integral part of the review process.

# Introduction

The primary characteristic of Michigan’s sand dunes is change--continual change in the natural forces creating the dunes and recently accelerated human change in the uses made of the dunes. The interface between lake and land, where the dunes are created, is a unique zone which has in recent years drawn public attention to protect the many resources and ecological functions associated with it. Because the shore zone is a vigorously active one, natural changes are especially significant. Changes may be more sudden, more profound, and perhaps more frequent than changes in other land units of comparable size. Interacting with natural causes are human induced coastal changes which are significant because coastlines are the site of intense human activity due to growing accessibility and expanded technological opportunities and economic demands. This characteristic of change or flux, seen in the context of both natural and human causes, quickly raises the notion of fragility--the relative ability of dynamic coastal systems to accommodate or tolerate change and, yet, to remain viable. It becomes imperative to attempt to understand those forces which operate naturally and their interaction with those which are introduced by man through the use of coastal resources.

## Purpose of the Study

This study represents a first step toward the identification and assessment of the environmental impact of land-based sand extraction and its significance to the continued viability of both natural and man-made systems. Results are necessarily preliminary in that they represent the application of limited background research to the examination of both an exceedingly complex set of environmental factors, and the ever evolving interdisciplinary field of impact analysis.

It must be noted that no existing method of impact assessment may be adapted quickly or easily for application to Michigan’s sand dunes nor can all the parameters of such a method be completely or finally specified. Impact assessment is still a developing field both conceptually and methodologically. Each study, each application to a specific human activity adds measurably to knowledge of how to proceed. Also virtually no work has been done on the environmental impact of sand dune mining itself. The unique characteristics of sand dune mining, and the fact that Michigan is one of the few places in the U. S. where mining is conducted make it difficult to portray the impact processes associated with Michigan’s sand dunes. The objective of this report is to provide the necessary ecological perspective and to suggest the appropriate criteria and methodology for environmental review of proposed mining, activities.

## Study Methodology

A major share of the effort on this project was devoted to an assessment of the state of knowledge regarding terrestrial sand mining. An initial survey of coastal states was made to learn of other experiences with similar resource pressures and management techniques. Results of this survey indicated that terrestrial sand extraction operations in other states are either no longer tolerated (the majority of states now protect dunes rather thoroughly), or are not of sufficient dimension to require any sort of comprehensive decision making or impact assessment mechanism. In no state was there located an instance of significant coastal dune mining.

Given this verification of the unique circumstances surrounding the use of Michigan’s sand dunes, an exhaustive search was conducted to assemble a body of literature dealing with terrestrial sand extraction generally, and mining in coastal or dune areas more specifically. No systematic consideration was found of mining circumstances similar to those in Michigan’s coastal dunes. Dune mining and management literature proved to be oriented largely to reclamation. Original research which might be useful for analytical purposes was found to be sparse at best.

Interviews with researchers and administrators, and visits to mining sites, were conducted concurrently with the above procedures in order to gain additional information. While expert opinion and preliminary findings were invaluable to the success of the study, it was found that much of the original research which might be most valuable in gaining understanding of the interaction of mining with dune ecosystems remains to be done. Although preliminary findings of current research were freely shared with project staff, final results were not yet available and further limited the base of knowledge.

The final investigative phase of the study involved the review of environmental impact analysis techniques and applications of impact assessment methods to coastal or resource circumstances other than sand mining.

This report, based upon resources available, synthesizes the basic ecological concepts and principles and available sand mining knowledge into a basic set of considerations for mining in coastal dunes. Further research will be necessary to extend or expand upon methods suggested in this study.

Section I of this report outlines the characteristics of sand mining and the impacts which are likely to be generated by that activity.

Sections II-III detail •the environmental interests affected by sand mining and provide the basis for understanding sand dune's as a dynamic natural environment.

Section IV discusses the basis for evaluating the aesthetic resources associated with sand dunes.

Section V establishes the criteria for assessing the socio-economic impact of barrier dunes on industrial, agricultural, and other specific land use activities.

Section VI is a suggested system of impact assessment specifically for sand mining on the barrier dunes of Michigan.

# I. Sand Mining

Mining in its most cautious, responsible form, might well be described as "the recovery of the mineral" followed by "the recovery of the land. " Certainly such a balanced perspective allows a better understanding of the realities of mineral extraction viewed against human values and the passage of time. It is precisely this view of mining as an agent of change which provides the theoretical basis for impact assessment concepts.

The simple notion of mining as the causative factor suggests an operational continuum of mining activities extending "cause" from exploitation to reclamation and finally to redevelopment or abandonment. It is the purpose of this section to describe briefly the nature of this operational continuum and the suboperations of which it is comprised. Subsequent portions of this report will describe categories of impact and their interrelationships.

Sand mining as it has been defined for the purposes of this study includes all terrestrial or land-based sand extraction within Michigan's coastal area. Excepted from consideration here are all subaqueous coastal zone operations.

## Methods of Mining

Conventional practices have further defined sand mining as it is conducted along Michigan's western shoreline. Current extractive practices call for either pit or dredge mining or a combination of the two.

Pit mines utilize clamshell or front end loaders to deliver sand to some intermediate means of transport, usually a conveyor. They tend to be shallow, rarely exceeding 100 feet, of limited areal extent, and are characterized by very low production of waste material. Lakes and ponds may be created if the watertable, is penetrated and extensive filling is not conducted.

Dredge mines involve continuous removal and processing of sand through the use of aquatic platforms and hydraulically powered pipelines. They are characterized by a similarly low production of waste material and by the eventual creation of lakes or ponds.

Processing procedures vary to a minor degree depending upon the mode of transport employed, but most sand processed on-site is subjected to three basic procedures: (1) washing to remove impurities, (2) drying to dewater washed sand, and (3) classifying to separate sand by grain size. More complete discussions of the technological subtleties involved in sand extraction and processing have been offered by several authors. The reader is referred to other sources for more detail.

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Section VI is a suggested system of impact assessment specifically for sand mining on the barrier dunes of Michigan.

Processed sand is removed from the mining site and delivered to destination by any or a combination of three types of transport. Though it is uncertain which modes occur most frequently, transport types may be ranked by tonnage hauled, with truck transport leading, followed by rail, and then water.

## Operational Considerations

It is useful from an analytical standpoint to display the actions and installations (change producing agents) included in sand mining in a sequential format for ease in categorization and to gain some sense of transition with time. As is usual, such a simplistic organizational approach must admit to minor sequential inaccuracies but, nevertheless, offers an attractively simple means of visualizing sand mining activities. Cross-referencing has been employed to reduce the inherent inaccuracy in this method.

The following list describes four major subcategories of mining activities: (1) site and structural design, (2) site preparation and facility construction, (3) operations, and (4) redevelopment or dereliction.

## List of Mining Features and Activities

### A. Site and Structural Design

- 1. Processing Plant
- 2. Accessory Buildings
- 3. Antennas, Towers, Stacks and Conveyer Lifts
- 4. Parking Lots and Paved Surfaces
- 5. Open Storage
- 6. Closed Storage
- 7. Conveyor and Pipe Lines
- 8. Barge and Transport Facility
- 9. Rail and Transport Facility
- 10. Truck and Transport Facility
- 11. Roadways
- 12. Utility Lines and Corridors
- 13. Fencing and Other Boundary Enclosures
- 14. Lighting Systems
- 15. Sound (Public Address) Systems

### B. Site Preparation and Facility Construction

- 1. Clearing
- 2. Stripping
- 3. Dredging
- 4. Excavating
- 5. Filling
- 6. Transport of Equipment and Materials
- 7. Erection of Plant and Accessory Structures
- 8. Installation of Utilities

### C. Operations

- 1. Vegetation Displacement Disposal
  *Transplanting*
- 2. Storage
  *Overburden Stockpile*
  *Waste Sand*
  *Fines and Contaminant Dump*
  *Mobile and Stationary Equipment*
- 3. Extraction
  *Dredge*
  *Pit*
- 4. Processing
  *Washing*
  *Drying*
  *Classifying*
- 5. Shipping
  *Barge Transport*
  *Rail Transport*
  *Truck Transport*
- 6. Landscaping and Reclamation
  *Nursery*
  *Buffer Planting*
  *Regarding*
  *Soil Restoration*
  *Revegetation*

### D. Redevelopment or Dereliction

- 1. Land Use

- 2. Site Plan
- 3. Abandonment

For each activity in the four subcategories, the major environmental-aesthetic-social-economic impact is listed first, as part of the definition of the activity, followed by specific impact considerations associated with it. The complete list of activities is also reproduced in the impact assessment matrix in Section VII of this report.

# Sand Mining Impact Considerations

## A. Site and Structural Design

### 1. Processing Plant

Location and design features of structural elements devoted to washing drying and classifying of sand as well as those structures and machines filling some supportive capacity. Considerations may include:

- dimensions and extent of structural elements
- dispersion or concentration of structural elements
- color, and texture of construction materials
- architectural forms chosen
- spatial organization of structural elements
- adjacent architectural forms or environmental setting
- integration of impact mitigating technology with structural
- and site design (acoustical and vibration controls)

Other related categories:

- site and structural design (all)
- site preparation and facility construction/erection of plant and accessory structures
- site preparation and facility construction/clearing operations-landscaping and reclamation (all)
- redevelopment or dereliction (all)

### 2. Accessory Buildings

Physical and aesthetic implications of auxiliary buildings (offices, gatehouse, garages . . . ) their integration into comprehensive site plan and architectural treatment. Considerations may include:

- dimensions and extent of structural elements
- dispersion or concentration of structural elements
- color and texture of construction materials
- architectural forms chosen
- spatial organization of structural elements
- compatibility with adjacent architectural forms or environ mental setting

Other related categories:

- site preparation and facility construction/clearing
- site preparation and facility construction/erection of plant
- and accessory structures
- site and structural design (all)
- redevelopment or dereliction (all)
- operations-landscaping and reclamation (all)

### 3. Antennas, Towers, Stacks and Conveyor Lifts

Placement and treatment of aerial or very elevated structures. Considerations may include:

- height of structural element
- visibility distance
- relationship to vertical elements in adjacent environment
- (natural and architectural)
- color and texture of construction materials
- form of structural element
- hazard to air navigation

Other related categories:

- site preparation and facility construction/clearing
- site and structural design (all)
- redevelopment or dereliction (all)
- operations-landscaping and reclamation (all)

### 4. Parking Lots and Paved Surfaces

- Nature and extent of hard surfaced site features. Considerations may include:
- area and extent of paved surface
- relative permeability of surface
- runoff control structures
- method of dust control
- active or passive use
- potential hazard of leakage from vehicles

Other related categories:

- site and structural design/roadways
- site preparation and facility construction/clearing
- operations-landscaping and reclamation (all)
- redevelopment or dereliction

### 5. Open Storage

- Nature and use of unconcealed, unenclosed, temporary of permanent
- storage of materials or equipment. Considerations may include:
- storage of hazardous substances (flammable, explosive, toxic
- or unstable materials)
- nature of surrounding environment
- potential hazard from tampering with stored equipment
- period of storage use
- visibility of stored materials
- proximity to adjacent uses whose safety may be
- jeopardized
- integration of storage site with comprehensive site plan

Other related categories:

- site preparation and facility construction/filling
- site preparation and facility construction/transport of equipment and materials
- site preparation and facility construction/installation of
- water, sewer and power
- site and structural design (all)
- operations-storage (all)
- redevelopment or dereliction (all)

## 6. Closed Storage

- Design and use of concealed or enclosed temporary or permanent
- storage of materials or equipment. Considerations may include:
- storage of hazardous substances (flammable, explosive, toxic or unstable materials)
- potential hazard from tampering with equipment
- nature of surrounding environment
- architectural forms chosen
- visibility of structure
- integration of storage site with comprehensive site plan

Other related categories:

- site preparation and facility construction/filling
- site preparation and facility construction/transport of equipment and materials
- site preparation and facility construction/installation of water, sewer and power
- site and structural design (all)
- operations - storage/fines and contaminant dump
- operations - storage/mobile and stationary equipment
- redevelopment or dereliction (all)

## 7. Conveyor and Pipe Lines

Routing, extent and dimensional characteristics of mechanical and

hydraulic transport lines delivering sand from pit excavations to

processing plant. Considerations may include:

- length, elevation and capacity of delivery line
- color and texture of construction material
- form and configuration of structure
- introduction of barrier into habitat
- visibility of structure
- compatibility with surrounding environment and adjacent uses

Other related categories:

- •site and structural design (all)
- operations-extraction/dredge
- operations-extraction/pit
- •redevelopment or dereliction (all)

## 8. Barge Transport Facilities

Placement and type of navigational, mooring and loading structures for the removal from site of washed sand. Considerations may include:

- pre-existing navigational characteristics
- scale of structural elements
- color and texture of construction materials
- integration with comprehensive site plan
- compatibility with adjacent environment or architectural forms
- distance at which structure is visible

Other related categories:

- site preparation and facility construction/dredging
- site preparation and facility construction/transport of
- equipment and materials
- site preparation and facility construction/clearing
- site and structural design (all)
- operations-shipping/barge transport
- redevelopment or dereliction (all)

## 9. Rail Transport Facilities

Railspur, switching, car storage and loading structures for the removal of processed sand from site by railcar. Considerations may include:

- dimensional characteristics of structural elements
- color or texture of construction materials
- architectural forms chosen
- integration with comprehensive site plan
- location and compatibility with adjacent environment or
- architectural forms
- distance at which structure is visible

Other related categories:

- site preparation and facility construction/transport of
- equipment and materials
- site preparation and facility construction/clearing
- site and structural design (all)
- operations-shipping/rail transport
- redevelopment or dereliction (all)

## 10. Truck Transport Facilities

Traffic, garage, repair, and loading structures for the removal of processed sand from site by truck. Considerations may include:

- dimensional characteristics of structural elements
- color or texture of construction materials
- architectural forms chosen
- integration with comprehensive site plan
- location and compatibility with adjacent environment or architectural forms
- distance at which structure is visible

Other related categories:

- site preparation and facility construction/transport of equipment and materials
- site preparation and facility construction/clearing
- site and structural design (all)
- operations-shipping/truck transport
- redevelopment or dereliction (all)

## 11. Roadways

Design features and composition of roads introduced, modified or used on or offsite and their attendant traffic control and safety features. Considerations may include:

- locations and area surfaced
- relative permeability
- runoff control structures
- method of dust control
- vegetation maintenance methods

Other related categories:

- site and structural design (all)
- operations-vegetation displacement/disposal
- operations-vegetation displacement/transplanting
- operations-shipping/truck transport
- landscape and reclamation (all)
- redevelopment or dereliction (all)

## 12. Utility Lines and Corridors

Routing, physical dimensions, and landscape aspects of water, sewer, power or communication cable rights-of-way. Considerations may include:

- area and extent of corridors
- integration with comprehensive site plan (common rights-of-way)
- method of vegetation management
- choice of suspended or buried cables
- height of suspension poles
- corridor configuration (ascending/descending, straight/ curved . .
- compatibility with adjacent uses or surrounding environment.

Other related categories:

- site preparation and facility construction/installation of water sewer and power
- site and structural design (all)
- operations - landscaping and reclamation (all)
- redevelopment or dereliction (all)

## 13. Fencing and Other Boundary Enclosures

Routing, height, opacity, and composition of mechanical or natural boundary enclosures or barriers. Considerations may include:

- type(s) of enclosure and material employed (fence, trench, hedge, windbreak . .
- visibility as a function of height, transparency, reflectivity and proximity
- integration with lighting systems
- purpose of enclosure (concealment, isolation, access barrier,. environmental control)
- relationship to areas of demonstrated potential hazard
- compatibility with surrounding environment
- integration with comprehensive site plan

Other related categories:

- site preparation and facility construction/dredging, excavating, filling
- site and structural design (all)
- operations - extraction/dredge, pit
- operations - extraction/shipping (all)
- landscaping and reclamation (all)
- redevelopment and/or dereliction (all)

## 14. Lighting Systems

Scope, intensity and extent of illumination systems. Considerations may include:

- area enclosed by lighting system
- visibility of illuminated area as function of height, intensity and exposure
- type and intensity of illuminating technology
- integration with boundary enclosures
- relationship to areas of demonstrated potential hazard
- period of illumination (day of week, time of day)
- compatibility with adjacent uses and surrounding environment
- integration with comprehensive site plan
- potential inhibitive effect on nursery and revegetation plantings

Other related categories:

- site preparation and facility construction/dredging, excavating, filling
- site and structural design (all)
- operations - extraction/dredge, pit
- operations - extraction/shipping (all)
- operations - landscaping and reclamation/nursery, buffer planting, revegetation

## 15. Sound (Public Address)

Potential volume, scope and distribution of broadcast stations for on site sound transmission systems. Considerations may include:

- period of operation (day of week and time of day)
- directionality of broadcast points
- potential broadcast power and audible range
- acoustic modification potential of adjacent environment
- background sound levels of adjacent community
- compatibility with adjacent uses and surrounding environment

Other related categories:

- site and structural design (all)

- operations - landscaping and reclamation/buffer planting

## B. Site Preparation and Facility Construction

### 1. Clearing

Destructive removal of vegetal cover by grubbing heavy plow or burning. Alternatively, the deliberate and informed extraction of selected types or specimens for preservation and replanting. Considerations may include:

- procedure to be used (alternative type and sequence)
- technology to be employed (specific machinery and deployment)
- identification of critical areas requiring temporary stabilization

Other related categories:

- operations-clearing/vegetation disposal/transplanting
- operations-landscaping and reclamation/nursery, buffer planting

### 2. Stripping

Removal of organic soil horizon covering sand deposits which are to be extracted. "Scalping" accomplished through plowing and grading procedures. Considerations may include:

- procedure to be used for "scalping" top soil (alternative type and sequence)
- technology to be employed (specific machinery and deployment)
- temporary or permanent stabilization of adjacent no-mine or topsoil stockpile areas.

Other related categories:

- operations storage/overburden stockpile
- operations-landscaping and reclamation/regarding, soil restoration

### 3. Dredging

Enlargement or deepening of existing water body or creation of a new or conjoining water body for the purposes of navigation or water delivery. Considerations may include:

- procedure to be used for dredging (alternative type and sequence)
- technology to be employed (specific machinery and deployment)
- schedule and equipment to be used for maintenance dredging
- method for disposal of dredge spoil
- method of bank stabilization and erosion control
- plan for installation of navigational structures
- potential impact on water quality

Other related categories:

- site and structural design/barge transport facilities
- operations-extraction/dredge or pit
- operations-shipping/barge transport
- redevelopment or dereliction (all)

### 4. Excavating

Creation of a hole, pit, or cavity for the purpose of extracting a useful substance, clearing passage or preparing for a structural foundation. Considerations may include:

- procedure to be used (alternative type and sequence)
- technology to be employed (specific machinery and deployment)
- identification of areas requiring temporary or permanent stabilization
- security method for hazardous areas

Other related categories:

- site and structural design/fencing or other boundary enclosure
- extraction (all)
- landscaping and reclamation (all)
- redevelopment or dereliction (all)

### 5. Filling

Depositing of waste or fill material into a dry or water filled depression for the purpose of achieving an elevated, dry, or planar land surface, or for the purpose of disposing conveniently (though not necessarily wisely) of non-valuable materials. Considerations may include:

- procedure to be used for filling (alternative type and sequence)
- substance to be buried (stability and toxicity)
- technology to be employed (specific machinery and deployment)
- site plan and expansion projection for plant and site
- displacement of biota and alteration or destruction of habitat

Other related categories:

- site and structural design (all) operations-storage/waste sand, fines and contaminant dump redevelopment or dereliction (all)

### 6. Transport of Equipment and Materials

Delivery and departure of equipment and materials necessary for the construction and operation of the mining site and related structures. Considerations may include:

- mode of transport (barge, rail or truck)
- substance or items to be transported (weight, bulk, volatility, and other special hazard)
- period of transit (time of week, time of day)

Other related categories:

- site and structural design (all)
- operations-shipping (all)

### 7. Erection of Plant and Accessory Structures

Preparation of site through grading and excavating procedures, installation of infrastructure elements for subsequent tie-in to adjacent structural elements (utilities, product delivery and processing lines, access roads . . . ), fabrication of structural elements, and assembly of machinery. Considerations may include:

- procedure to be used in preparation phase (excavation, blasting . .
- materials to be used in fabrication and assembly of structures and machinery and sources of those materials.
- technology to be employed in construction (specific machinery and deployment)
- schedule of work (day of week, time of day)
- potential hazard to adjacent persons and structures or to community at large (fire, vibration, explosion, toxic substances) and method of managing risk.
- method of waste disposal

Other related categories:

- site preparation and facility construction (all)
- site and structural design (all)
- operations-clearing (all)
- operations-landscape and reclamation (all) redevelopment or dereliction (all)

## 8. Installation of Utilities

Clearing, excavation, and grading of corridors to accommodate installation of water and sewer pipelines, buried cables or power and telephone poles. Considerations may include:

- alternative delivery, disposal or communication modes
- standard procedure to be used for installation
- technology to be employed (specific machinery and deployment)
- schedule of work (day of week, time of day)
- interruption of services to adjacent users
- introduction of temporary or permanent hazard
- method of short and long-range vegetation management in utility corridor (chemical or mechanical/toxicity)

Other related categories:

- site preparation and facility construction/clearing
- site preparation and facility construction/stripping
- site preparation and facility construction/excavating
- operations-clearing (all)
- operations-landscape and reclamation (all)
- redevelopment or dereliction (all)

# C. Operations

## 1. Vegetation Displacement

### a. Disposal

Destruction, sale, re-use or other elimination of vegetal debris (root, stem, and crown material). Considerations may include:

- method of disposal (burning, stockpiling, burial, chipping for land application, volunteer cutting and hauling, sale for commercial or domestic use)
- visual intrusion of temporary of permanent debris heaps or disposal activity
- amount of vegetation to be eliminated
- relative immediate safety, and freedom from nuisance of disposal method
- compatibility of disposal method with adjacent uses and environmental setting
- risk from disposal methods which do not return nutrients to soil

Other related categories:

- site preparation and facility construction/clearing operations-landscaping and reclamation/nursery, buffer planting, soil restoration, revegetation
- redevelopment or dereliction (all)

### b. Transplanting

Conservation of plant material by selective digging and removal to a temporary nursery site or directly to replanting location. Considerations may include:

- procedure to be used to determiner species and individuals to be saved
- technology to be employed (specific machinery and deploy-men t)
- method of transplanting (horticultural procedures)
- detailed schedule (time out of ground, time of year, time of day . .
- adequacy of personnel and machinery
- integration of transplanting schedule with mining schedule
- integration of transplanting schedule with nursery operations, buffer planting, and revegetation efforts
- integration of transplanting schedule with site plans for proposed development

Other related categories:

- site preparation and facility construction/clearing
- operations-landscaping and reclamation/nursery, buffer planting, and revegetation

## 2. Storage

### a. Overburden Stockpile

Temporary depositing of stripped or scalped Lop soil into stockpiles awaiting reclamation procedures. Configuration of the stockpile varies with the configuration of the sand deposit and the procedure for its removal. Considerations may include:

- location and size of pile to be stored (proximity and convenience should guide actions except where potential wave action demands additional set back or when considerable advantage may be had by strategically locating stockpile)
- procedure for handling overburden

- technology to be employed (specific machinery and deployment)
- method of controlling runoff and erosion
- method of temporary or permanent stabilization
- integration with landscape related aspects of comprehensive site plan
- landscape character of overburden stockpiles (physical form, degree of revegetation)
- compatibility with adjacent uses and environmental setting
- length of storage period and scheduling

Other related categories:

- site preparation and facility construction/stripping
- operations-landscaping and reclamation (all)

#### b. Waste Sand

Extracted sand not economically exploitable due to high impurity content and/or inappropriate grain characteristics. Typically used to fill water basins, moderate steep slopes, create elevated embankments, or simply stockpiled. Considerations may include:

- amount of waste sand to be relocated
- procedure for moving sand
- technology to be employed (specific machinery and deployment
- form or configuration of deposit created
- method of stabilizing stockpile or fill area
- integration with landscape related aspects or comprehensive site plan
- compatibility with adjacent uses and surrounding environment
- length of storage period and scheduling

Other related categories:

- site preparation and facility construction/dredging, excavating, filling
- operations-extraction/dredge, pit
- operations-landscaping and reclamation (all)
- redevelopment and dereliction (all)

#### c. Fines and Contaminant Dump

Stockpiling, dumping or burial of waste or byproducts such as clay particulate (“fines”), calcium carbonate, or iron minerals. Considerations may include:

- toxicity and stability of waste material
- amount of material for disposal
- procedure for moving and storing material
- technology to be employed (specific machinery and deployment) form or configuration of deposit created
- method of stabilizing stockpile or fill area
- integration with landscape related aspects of comprehensive site plan
- compatibility with adjacent uses and surrounding environment
- length of storage period and scheduling

Other related categories:

- site preparation and facility construction/filling
- operations-processing/washing, classifying
- operations-landscaping and reclamation (all)
- redevelopment or dereliction (all)
- site and structural design/fencing or other boundary enclosure, lighting systems

#### d. Mobile and Stationary Equipment

Idle, standing or inoperative remote stationary machines, portable, or vehicular equipment. Considerations may include:

- location of equipment or machines
- number and type of machinery or equipment
- length of storage period and scheduling
- compatibility with adjacent uses and surrounding environ-men t
- visibility distance
- method of managing potential hazard (supplemental storage of hazardous fuels or materials, tampering)

Other related categories:

- site and structural design/parking lots and paved surfaces, open storage, closed storage
- site preparation and facility construction (all)
- operations-extraction/dredge, pit operations-shipping/barge transport, rail transport, truck transport
- operations-landscaping and reclamation/regarding, soil restoration, revegetation

## 3. Extraction

#### a. Dredge

Removal of sand by the use of hydraulic (suction) pipelines and water jets from dune embankments or the bottoms of mining ponds. Considerations may include:

- maximum depth to mine floor
- maximum depth to bottom of ponds
- areal extent of extractive operations (acreage as percentage of cell and property)
- dune system in which extraction may take place (active or fossil)
- utilization of directional or sequential working techniques to minimize and organize effects (following contour of dune fields or types, working across instead of along views
- violation of critical ecological or landscape features (destruction of fragile habitat, breaching lakeward dune crest
- impairment of critical beach-dune sand exchange process by breaching of lakeward dune ridge

- dimensions and configuration of resulting ponds or lakes relative to proposed reclamation procedures and final site plan (slope of basin walls suitable for subsequent use, shoreline configuration conducive to circulation and thus, quality of water, integration of pit or pond features with design principles of final site plan
- creation and method of control for navigational, shore erosion, land subsidence, inundation or other water related hazard

Other related categories:

- site preparation and facility construction/clearing, stripping, dredging
- operations (all)
- redevelopment or dereliction (all)

**b. Pit**

Removal of sand from excavation sites by the use of mechanical loaders or shovels. Active portions of pit mines are land based though bodies of water may result. Considerations may include:

- maximum depth of mine floor
- areal extent of extractive operation (acreage as percentage of cell and property)
- dune system in which extraction may take place (active or fossil)
- utilization of sequential or directional working techniques to minimize and organize effects (following contour of dune fields or types, working across instead of along views)
- violation of critical ecological or landscape features
- integration of pit features and reclamation procedures with design principles of final site plan
- creation and methods of control for erosion, subsidence, or other pit related hazard

Other related categories:

- site preparation and facility construction/clearing, stripping, excavating
- operations (all)
- redevelopment or dereliction (all)

## 4. Processing

**a. Washing**

Removal of unwanted, adulterating substances, typically accomplished by the wet chemical process termed flotation. Considerations may include:

- handling, filtering, reuse and discharge of water
- sediment and erosion control methods
- storage and disposal of chemical agents
- visible emissions from stacks, vents
- noise

Other related categories:

- site and structural design/processing plant, barge transport facilities, rail transport facilities, truck transport facilities
- operations-extraction/dredge, pit
- operations-storage/waste sand, fines and contaminant dump
- operations-shipping (all)

**b. Drying**

Dewatering of sand wetted through mining or washing procedures. Commonly accomplished by passage through a heater air chamber. Considerations may include:

- handling, filtering, reuse and discharge of water
- sediment and erosion control methods
- visible emissions from stacks, vents
- noise
- fugitive dust

Other related categories:

- site and structural design/processing plant, barge transport facilities, rail transport facilities, truck transport facilities
- operations-extraction/dredge, pit
- operations-storage/waste sand, fines and contaminant dump
- operations-shipping (all)

**c. Classifying**

Sorting or separation of sand by grain size. Additional procedures may be carried out for the removal of magnetic particles. Considerations may include:

- visible emissions from stacks, vents .
- noise
- fugitive dust
- vibration

Other related categories:

- site and structural design/processing plant, barge transport facilities, rail transport facilities, truck transport facilities
- operations-extraction/dredge, pit
- operations-storage/waste sand, fines and contaminant dump
- operations-shipping (all)

## 5. Shipping

**a. Barge Transport**

- Loading procedures and method for conveyance of washed sand
- from mining site by water borne carrier (barge, ship, etc. ).
- Considerations may include:
- - number and type of vessels to be used (maximum)
- - dimensional characteristics of vessel
- - adequacy of adjacent navigational structures (channel
- width, turning space . .

- schedule of operation (day of week, time of day, average mooring period)
- competitive demand from other water uses
- prop turbulence
- spillage and erosion control methods
- method of loading (technology and deployment)
- visibility distance of barge facility with moored vessel(s)
- method of security for hazardous areas and procedures
- noise (loading and navigation)
- vibration (loading and navigation)
- fugitive dust (loading and navigation)
- maintenance dredging schedule

Other related categories:

- site and structural design/barge transport facilities
  - site preparation and facility construction/transport of equipment and materials
- • operations-processing/washing, drying, classifying

**b. Rail Transport**

- Loading procedures and method for conveyance of processed sand
- from mining site via railcar. Considerations may include:
- - number and type of railcars to be used (maximum)
- - schedule of operation (day of week, time of day)
- - spillage control methods
- - method of loading (technology and deployment)
- - visibility of rail facility with cars standing on siding
- - method of security for hazardous areas and procedures
- - noise (loading and running)
- - vibration (loading and running)
- - fugitive dust (loading and running)
- - right of way maintenance responsibilities and policies
- - adequacy of existing rail and road crossing network

Other related categories:

- • site and structural design/rail transport facilities
- • site preparation and facility construction/transport
- of equipment and materials
- • operations-processing/washing, drying, classifying

**c. Truck Transport**

- Loading procedures and method for conveyance of processed
- nd from mining site by open or closed truck. Considerations
- may include:
- number and type of trucks to be used (no. of wheels,
- tandem units
- schedule of operation (day of week, time of day)
- spillage control methods
- visibility of truck facility with typical complement of
- standing vehicles
- method of security for hazardous areas and procedures
- noise (loading and running)
- vibration (loading and running)
- fugitive dust (loading and running)
- road maintenance responsibilities, schedules, and capacities
- placement and design features of exit/entrance points
- (blind curves and hills, visibility and stopping distance,
- advance caution warning, hazard from road spillage, traffic
- control instruments, clearly marked intersections)

Other related categories:

- site and structural design/truck transport facilities
- site preparation and facility construction/transport of
- equipment and materials
- operations-processing/washing, drying, classifying

## 6. Landscaping and Reclamation

**a. Nursery**

Creation of horticultural area suitable for the establishment and maintenance of propagated or transplanted vegetal stock

necessary for landscape related activities. Considerations may include:

- amount of space devoted to nursery
- location relative to planting-out sites (convenience and efficiency)
- climatic aspect of nursery area (light, shelter and other conditions for vigorous growth, similarity of nursery site conditions to those of revegetation sites)
- soil and water characteristics or improvements
- species stocked
- genetic source of stock (transplanted or propagated indigenous species or selected cultivars)
- budget, expertise, and personnel available for horticultural requirements
- machinery to be employed and adequacy relative to rate and type of revegetation
- maintenance schedule and requirements
- integration of nursery production with clearing and revegetation rates and procedures
- method of preventing damage by public access or vandalism

Other related categories:

site and structural design (all)

- site preparation and facility construction/clearing
- operations-vegetation displacement (all)

- operations-landscaping and reclamation (all)
- redevelopment or dereliction (all)

### b. Buffer Planting

Planned location and design of bodies of vegetation to modify the conspicuousness or intensity of technological effects (noise, visual intrusion, and air pollution). To be effective, visual and noise control plantings must be integrated with earthen barriers. Considerations may include:

- purpose of planting (concealment, noise absorption, air filtration)
- integration with earthen forms
- limitations of the moderating capacity of buffer planting applications
- adequacy of proposed planting design based on depth, height, density, areal extent, or species composition
- maintenance requirements and programming
- integration of planting design with other site design features, adjacent uses and surrounding environment
- balancing amenity advantage with risk of camouflaged hazard

Other related categories:

- site and structural design (all)
- site preparation and facility construction/clearing
- operations-vegetation displacement (all)
- operations-landscaping and reclamation (all) redevelopment or dereliction (all)

### c. Regarding

Grading of mine floor to flat or nearly flat surface for subsequent structural development or, alternatively, Recontouring and smoothing of unmined sand into aerodynamically stable forms to minimize subsequent wind erosion and maximize opportunity for successful revegetation (principles also apply to overburden stockpiles). Considerations may include:

- procedure to be used (flat grading for subsequent redevelopment, or ecologically based restoration)
- technology to be employed (specific machinery and deployment)
- schedule of regrading operations
- overall site planning aspects displayed in plan-view and cross-sectional analysis
- sufficiently smooth final earth forms to assure uniform soil replacement and vigorous plant growth
- appropriateness of slopes relative to revegetation procedures (steep slopes may require all or many available stabilization techniques yielding indeterminate growth rates and vigor; moderate slopes demand less radical stabilization measures yielding more consistent growth)
- method of drainage control (surface and/or subsurface)
- method for control of public access, traffic, or vandalism
- integration with vegetative aspects of reclamation procedures
- integration with adjacent uses and environmental setting
- preservation or restoration of ecological integrity of on or off site areas

Other related categories:

- site and structural design (all)
- site preparation and facility construction/stripping, dredging, excavating, and filling
- operations-extraction (all)
- operations-storage/overburden stockpile, waste sand, fines and contaminant dump
- operations-landscaping and reclamation (all)
- redevelopment or dereliction, (all)

### d. Soil Restoration

Spreading or reapplication of stockpiled organic soil over the surface of regraded sand forms. Considerations may include:

- procedure to be used (alternative type and sequence)
- technology to be employed (specific machinery and deployment)
- approximate thickness of final surface material
- composition of final surface material (soil analysis)
- method of drainage control (surface and/or subsurface)
- sufficiently smooth final surface to assure slope stability, and vigorous plant growth
- method for control of public access, traffic or vandalism

method(s) of stabilization to be employed Other related categories:

- site preparation and facility construction/stripping, dredging, excavating, and filling
- operations-extraction (all)
- operations-storage/overburden stockpile, waste sand, fines and contaminant dump
- operations-landscaping and reclamation (all)
- redevelopment or dereliction

### e. Revegetation

Successful introduction or reintroduction of plant cover of specified landscape type (grass, shrub, open or closed tree canopy, or combination) or species composition. Considerations may include:

- overall plan of final plant communities by landscape type and species composition
- vegetative stabilization method(s) and rate (type of cover crop or transplanting)
- mechanical stabilization method(s) and rate (fencing, brush matting, buried fascines or mulch)
- sowing or transplant methods to be used

- rate, type, and method of application for fertilizers or soil amendments
- seasonal revegetation schedule and rate
- climatic aspect of site and provision of adequate moisture
- maintenance requirements and schedule
- method for prevention of damage by traffic or animals
- adequacy of nursery stock for planting rate, volume and type

Other related categories:

- site and structural design (all)
- site preparation and facility construction/clearing, stripping, dredging, excavating, and filling
- operations-vegetation displacement (all)
- operations-extraction/dredge, pit
- operations-storage/overburden stockpile, waste sand, fines and contaminant dump
- operations-landscape and reclamation (all)
- redevelopment or dereliction (all)

## D. Redevelopment or Dereliction

### 1. Land Use

Zoning or land use classification applied to mining properties in whole or in part, and the direction of potential change ("higher" or "lower" use) upon the conclusion of mining activities. Considerations may include:

- type of use for which land is or may be classified prior to, during, or following mining activities (agricultural, recreation, commercial/industrial, residential
- distance from nearest urban center(s)
- competitive 'demand for proposed alternative uses
- desirability of expanded versus contained urban services
- importance of loss of other potential uses
- economic base of community
- social structure of community

Other related categories:

- site and structural design (all)
- operations (all)
- redevelopment or dereliction/site planning, abandonment

### 2. Site Planning

Nature, scope and detail of proposed or potential physical plans for subsequent non-mining development of worked out lands. Considerations may include:

- type of redevelopment proposed and allowed by land use classification
- integration of landscape aspects of reclamation with design elements of proposed final site plan (preplacernent of mature vegetation minimizing need for cutting, land forms preplanned to allow minimum excavation and filling for structural redevelopment, adaptability of existing road structure reducing need for further clearing
- ecological integrity of geological and biological alterations (stability of lakes, hills, vegetative communities
- relative energy dependence of proposed development based upon extension of services, travel time, structural efficiencies, and consumer types
- compatibility of proposed development with adjacent uses and surrounding environment

Other related categories:

- all categories

### 3. Abandonment

Contingencies for the abandonment of worked out or derelict mine sites. Considerations may include:

- sufficiency of bond money to cover full reclamation expenses
- removal or provision of security for hazardous areas
- method for disposal and stabilization of drainage structures, storage basins, and excavation cavities
- method for stabilization or abandonment of road network
- assignment of responsibility for any permanent structures left behind
- maintenance program and schedule for any permanent structures left behind

Other related categories:

- site and structural design (all)
- operations-extraction/dredge pit
- operations-storage (all)
- operations-landscaping and reclamation/regrading, soil restoration, revegetation
- redevelopment or dereliction (all)

# II. Sand Dunes: A Dynamic Natural Environment

Covering more than 12 percent of Michigan's coastal area are great expanses of sand dunes. A unique combination of natural factors and phenomena make these dunes a nationally unique resource, from the perspective of commercial and industrial applications as well as from the perspective of recreational and aesthetic values. Use and removal of sand dunes, however, often interrupt the active dune processes and interfere with the many natural systems inter-linked with dune structure, processes, and environment. A general understanding of the dynamic natural environment associated with Michigan sand dunes provides the basis for an understanding of the impacts resulting from sand dune uses and removal.

## Dune Origin

On the geological time scale the Great Lakes are very young, their origins dating from about 20,000 years ago. Their present form is the culmination of a complicated series of events including several glacial advances and retreats, and the subsequent tectonic uplift of the northern part of the basin. Hough gives a complete account of these events by radio carbon dating. The lakes have had various drainages at different stages, with a south drainage through the Chicago area occurring periodically. (Ragotzkie, p. 22).

Glacial sand deposition was due largely to the melting of ice and the release of rock material. For a time, the melting ice front progressed at the same rate as the forward movement of the ice causing much of the material to be deposited in a relatively narrow belt along the ice front (Brown 1936).

During the period that the Great Ice-sheet retreated northward across Michigan, extensive plains of gravel and sandy material were deposited by many streams which issued from the melting ice front. Sediment, varying from coarse sand to fine clay, was carried by the streams running into the Great Lakes and spread over the lake bottom. The coarser material was deposited near the shore where wave action worked it into sandy beaches, and the finer material was carried further out into deeper more quiet water. Many such deposits are located along the eastern shoreline of Lake Michigan (Heinrich, 1976).

Lake Michigan is also a notable example of sorting action by shore currents. The bluffs along the shore differ in height from a few feet to over 350 feet near Pt. Betsie and are composed of glacial material consisting of principally sand and clay. The waves working on the bluffs sort this material, and similarly carry the clay out to deeper water, and deposit the sand along the shore. The slow south-moving current along the eastern shore of Lake Michigan cuts into the shallows, depositing the sand along the Michigan shoreline.

Sediment along the beaches is picked up by the wind. Its place of deposition will depend on the size of the sediment and upon its weight. The light particles will be carried further than the heavier particles. With certain wind velocity the coarse sand may move in short leaps, the finer sand by longer leaps, while the clay may remain in suspension in air for long distances.

Dunes are formed by wind transport of marine sands. A prerequisite for dune formation is the occurrence of large sand deposits at a sufficient level for the surface area to dry out between high tides and wave action (Barnes, 1977). Transportation by the wind is now taking place in Michigan in much the same manner as it occurred immediately after the glacial period. The shifting sand dunes of Lake Michigan are a clear example of this wind activity.

The coarser sands which move more slowly are concentrated into dunes, the finer material being winnowed up and carried away. Sand dunes, therefore, occur very close to the source of the sand or sediment picked up by the wind. Because of the high effectiveness of the wind in separating sediment according to sizes the sand contained in a dune is well sorted and generally of a uniform fineness (Brown. 1936, p. 17).

## Dune Description

The delineation of dunes is complicated by two principal factors. First, they are often quite mobile and consequently require a special approach to survey and inventory. Second, dunes come in a variety of shapes and sizes. When they are small, flat ridges, they are not easily distinguishable from other parts of the beachfront.

Dunes have developed primarily along the eastern shore of Lake Michigan. Two extensive tracts also occur along the northern shore in the Upper Peninsula in Mackinac County. The high reflectivity of bare sand cause these areas to stand out conspicuously on the photomosaic of Lake Michigan (Hands, 1970). These extensive sand tracts are characterized by a complex of active, transverse dunes. Usually no vegetation is found in the low, windblown or ‘blowout” regions extending along the central axis near shore toward the dune’s foreshore crest. Dunes of this type can reach a maximum of 200 feet. Another type of dune occurs further away from the beach. These larger dunes are actually immobilized sand hills that are less conspicuous because of a mantle of dense vegetation. Actual hills of dune sand are supposedly rare features on the world’s coasts and are indicative of an unusually abundant supply of sand and periodic strong winds. Along the southeastern shore, sand hills range from 75-200 feet in elevation (Olson, 1958, p. 44).

Bluffs of unconsolidated material form steep embankments along almost one-third of Lake Michigan’s shoreline. The entire southeastern shore alternates between bluffs, beaches and active dune areas. Some bluffs occur within the proximity of large sand deposits. In these areas windblown sand often coats the entire bluff with a sandy sheath. Dunes formed here are termed perched dunes. These may attain heights of approximately 300 feet.

All coastal dunes are changing, or reshaping in that a remodeling of the primary form is constantly under the degradational activity of the wind, combined with additions of sand (Scott, 1942).

The forms assumed by the blowing sand are different and require a brief discussion. An essential factor is vegetation. If the dune is completely covered by plant growth the dune is said to be fixed or stabilized. Where local blows are possible, however, the sand is removed to the leeward leaving furrows parallel to the wind direction. Often they are surrounded on all sides except the windward by a ridge curved in the form of a horseshoe. This is characteristic of the parabolic dunes which form concave to the wind and are typical of the area behind the fore dunes. Further development occurs in which the trench is elongated and the “toe area” is built up, sometimes to heights near 200 feet (Scott, 1942, p. 52). The elongation of the dune is accomplished by the removal of sand from the windward slope to the lee plus additional sand from the beach. This process resembles migration but the dune does not leave its source of supply - the beach.

As the dune is attacked by storm waves, eroded material is carried out and deposited offshore, where it alters the shore profile. Accumulating sand decreases the offshore beach slope thereby presenting a broader bottom to storm wave action. This surface absorbs or dissipates, through friction, an increasingly large amount of destructive wave energy that would otherwise focus on the beach. It is the capacity of the berm-and-dune system to store and yield sand to the adjacent submerged bottom that gives the system its outstanding ability to protect the shorelands.

Sand dune forms resulting from the complex set of natural phenomena operating within the coastal and shorezone area are numerous. The more common dune forms are: parabolic dunes, linear dune ridges, dune terrace, dune platform, domal dune, complex dune field, dune flat, marginal sand apron, and inter-dune lowland.

For the purpose of this study the term sand dune will apply to all sand dunes collectively defined by the arbitrary definition of Barrier Sand Dune Formation as " . . . that first dune assemblage whose forms display the greatest relative relief within the officially designated "sand dune areas its inland boundary is at the base of the assemblage's landward limit" (Buckler, 1978, p. 43). This is the first dune assemblage inland from the beach or adjacent to a low relief assemblage adjacent to the upper beach zone.

## Dune Dynamics

A few of the more important natural phenomena operating in the dynamic environment of sand dunes were selected for brief background discussion. In combination, these phenomena produce the more significant physical-biological impacts described later in this report.

## Sand Transport

The combined processes of wave action, currents, and wind move beach sand and constitute the same transport system. The unifying element in the system is the flow of sand, which in some locales amounts to over 100,000 cubic yards of sand per year. The bulk of the work in the system is accomplished by waves and currents which move the sand parallel to the shore (Barnes, 1976).

The primary driving force in the sand transport system is the energy of the waves, currents and wind. Changes in this energy can cause changes in the rate in which sand is moved. This in turn can produce changes in the volume of sand that comprises the beach. If the energy level is increased, as had clearly been the case with high lake levels of the past decade, then sand may be carried from a beach faster than it is carried to it and the sand supply of the beach may dwindle.

Though nature is the main control on energy changes in the sand transport system, man can cause important changes as well. Breakwaters, groins, and seawalls are examples of measures intended to reduce wave energy and sand transport. Sometimes such structures can be too arresting and disrupt the whole system. Examples of property owners who have lost or gained coastal land are common.

Since the sand transport system is such a pervasive component of the shore zone, almost any development situated there comes into contact with it. In many instances this contact results in damage to the development and the sand transport system.

A dune field can remain "alive" so long as the supply of sand and the force of the wind are not significantly reduced. Many actions both natural and human can cause reduction, including, for example, a decline in the size of the sand source area as a result of beach erosion, and the placement of structures in the water or beach area (Heinrich, 1976).

## Atmospheric Factors

The primary atmospheric condition affecting both the deposition of sand and the subsequent buildup of the dune is the wind. The wind moves sand either by rolling it along the ground or by sweeping it up and forward. In the latter case the advance commonly consists of short jumps, the grain being carried from a fraction of an inch to many feet, then dropped. Studies conducted by Cressey and others emphasize the importance of saltation, i. e. , the grains being lifted and carried in these short jumps.

The size, shape and composition of sand grains are of much importance. Heavier or larger grains are less easily lifted and they progress by shorter jumps, while the finest products of abrasion can be picked up by more gentle breezes and may settle outside the dune area. On surfaces which have been compacted, as by rain or snow, the individual grains tend to interlock and the wind does not easily move them.

Data from many observations indicate that. with common beach and dune sand, transportation begins with wind velocity of 6. 8 miles per hour (Cressey, 1928).

The direction of the wind plays a large part in dune accumulation. Where dunes are predominantly from one direction, much more regular forms arise and the dunes are linear; the movement of the dune is likewise pronounced. With more variable winds accumulation resembles a more circular hill instead of a ridge. The strength of the wind determines whether linear dunes shall be parallel or at right angles to the wind direction, the latter being common under low velocities, the former under higher velocities (Gatz and Changon, 1976).

The eastern Lake Michigan winds are most effective for dune construction since they approach the ridges from the beach and thus find exposures of sand available for movement and accumulation. Coming off the smooth surface of the lake these winds also have higher average velocities. Winds from other directions strike the dune complex where it is forested. Dune accumulation thus parallels the source of supply.

In the spring, Lake Michigan warms slowly keeping the region cooler over an extended period of time, thus preventing buds from opening too soon during early spring.

In the fall waters of Lake Michigan retain much of their summer warmth. This buffering effect in spring and fall make the shore area capable of supporting growing plants that are not found in other areas.

Wind is the transport agent for dune building and it also determines dune form and movement. If the sand supply is depleted through construction or excavation however, a process of local erosion occurs. An understanding of the dynamics of the particular system is necessary before any measures are planned that affect dune stabilization. Ranwell has estimated that a shoreline dune takes 50 years to reach maximum height. Likewise a dune would have moved landward sufficiently after 70-80 years for the development of new “embryo” dunes.

## Hydrologic Factors

The mechanism of the long-shore transport of sediment is readily understood. When a wave breaks, the up-rushing water on the beach carries with it a certain amount of sand and gravel. When the water does lose its momentum, it reaches the limit of advance and there is a momentary halt. Then the backwash occurs, and the water and its sand load flow down to the beach and back into the lake. If the waves strike the shore exactly at right angles, the beach material is moved back and forth over the same route and there is no lateral shirting of sand. Because of winds and currents, however, most waves strike the shore obliquely (Cressey, 1928, p. 16). When such waves break, the up-rush is at an obtuse angle to the shore. Under the action of these waves sand and beach detritus are moved up and along the beach by the up-rush and then directly down the beach by the backwash. This to-and-fro shifting accounts for sand and beach shingle traveling along the beach. This process is known as long-shore or littoral drift.

In addition to this transport of material on or near the beach, much sand is also shifted below the water by the drag of waves (Scott, 1942, p. 58).

As the original material of the drift is worked over by the waves and transported southward, distinct changes take place in it. The beach sand and gravel at the foot of the bluffs are fairly free from clay, for the latter is carried in suspension out into the lake. Large stones are rather rare but there is commonly a considerable proportion of coarse gravel known as the beach shingle and composed of crystalline and sedimentary rocks. These gravel pebbles are usually subangular and even the finer particles, such as sand are sharply-cornered. With wear from waves, the fragments of all sizes tend to become rounded. When exposed to the work of the waves pebbles and sand grains of less resistant minerals are rapidly abraded or decomposed (Hough, p. 31). The net result of the transportation process on both the eastern and western shore of Lake Michigan is that the final product which reaches dune country is mostly a fine quartz sand.

The process of sand transportation by long-shore currents is not wholly confined to the beach. The lakeward limit of sand transport is set by the depth of water in which larger storm waves agitate the bottom. The maximum depth is about 60 feet, and while sand at this depth is moved only during storms, there is a very considerable body of sand which is in the process of being slowly transported (Cressey, 1928). Thus the total bulk of sand in transit is divided between that being actively shifted by the littoral drift and the much larger reservoir of more slowly moving sand under the water. Where the littoral currents cease to be effective, accumulation therefore takes place; and from this large underwater reserve, sand is carried to the beach where it becomes available for the construction of dunes (Olson, 1953).

## Role of Vegetation

Plant life in the form of single plants, groups of plants and sparse to dense vegetation of herbs, shrubs and trees aids in the topographic formation of the coast and some backshores. The plant life is secondary to the mechanical forces in the development of some dune topography, but is most important in the stabilization and retention of the various forms after they have been developed. Plants are passive agents that alter wind action, but they are active agents in holding dune materials in place. Each shoreline plant plays a particular role, but it is usually the aggregation of plants that brings about changes and consequent stabilization.

The primary role of plants along the foredune is important more as small groups than as dense cover. The pioneer-dune forming plants influence the movement of wind-borne sand and generally cause more deposition in an area than would normally occur if they were not present.

The vigorous growth of the top part of dunes is often characteristic of these pioneer, dune-forming plants. Even when dead, the exposed upper parts of the plant may continue to act as screens.

The mechanical effects of underground parts of plants are complex. The fibrous root systems and adventitious roots from the joints or nodes along the stem act as very efficient sand binders. The rhizomes or root-stalks below the surface and the and the stolons or runners at or near the surface also serve in the same capacity.

The underground parts absorb water and selectively absorb some of the minerals present. This alteration of the moisture content and the chemical characteristics is a slow but significant change in the sands of dune fields of long duration. The shade produced by plants keeps the temperatures lower than those in uncovered sand and reduces the evaporation of water.

Plants have the ability to grow in three directions: horizontally, upward, and downward. In this manner they keep pace with deposition of sand and continue to alter the erosion cycle. The ability of plants to survive and reproduce themselves make them nearly perpetual agents for stabilization.

## Beach and Shore Biota

Living communities begin at the waters edge where simple forms of algae grow due to gentle wave action in the summer. As the high water line is passed, rooted plants appear, starting the sea rocket, bugseed and seaside spurge. Slightly further inland other plants appear: beach wormwood, marram grass, sand reed, little bluestem grass, Canada wild rye, beach pea, dune goldenrod, sand cress, hairy puccoon and bastard toadflax. These plants occur not only on the upper beach but on the foredune and other places of open, non-forested sand throughout the dunes.

Other plants occurring typically on the foredune and also in other dune areas are the dune willow, blue leaved willow, sand cherry, round leaved dogwood, wafer ash, and cottonwood. Some other typical plants of the open sandy beach are bittersweet, poison ivy, starry false salomon's seal, redosier dogwood, gray dogwood and common juniper.

Common birds of the beach include fulls, terns, and sandpipers. Often observed near shore are herons, common grackles, and swallows.

An interesting bird of this habitat is the Prairie Warbler; a bird with the bulk of its breeding range further south. It builds its nests in shrubs of the non-forested sandy areas, especially along the fore dune and just in the lee of it. It is the most common breeding bird of the dune community.

Box turtles and the American toad are often found in the open sand areas - the toads along the beach and the turtles up in the dunes.

Typical invertebrates indigenous to the dunes are the sand spider, burrowing spider, white tiger beetle, maritime grasshopper, long horned grasshopper and digger wasp (Jaworski, p. 17).

In the fall some insects migrate along the shore. Occasionally, large numbers of monarch butterflies can be observed.

A small, but important component of the beach and shore biota is, of course, the lengthening list of endangered and threatened species. This is discussed in a later section of this report.

## Wooded Dune Biota

The black oak dominates this habitat especially in the southern area of Michigan. An interesting tree of the dune area is Hill 's oak. Two species of serviceberry, the Juneberry and the Allegheny shadblow grow throughout the high dunes.

Ferns and flowering forbs inhabit the wooded portions of the dunes. Acknowledge species include: the marginal woodfern, christmas fern, grape fern, wild sasparilla, white baneberry, columbine, big-leaf aster, Canada mayflow and prince's pine. Trailing arbutus and groundpine often appear on north-facing slopes.

Some of the characteristic breeding birds of this habitat are yellow-billed cuckoo, Black-billed Cuckoo, Great Horned Owl, Screech Owl, Whip-poor-will, Harry Woodpecker, Downy Woodpecker, Red-bellied Woodpecker, Yellowshafted Flicker, Great Crested Flycatcher, Eastern Wood Pewee, Blue Jay, Blackcapped Chickadee, White-breasted Nuthatch, Tufted Titmouse, Brown Thrasher, Red-eyed Vireo and Scarlet Tanager.

Black-throated Green Warblers, a northern species have been observed in the summer months in the wooded dune hollows.

Mammals of this habitat include whitetail deer, raccoon, red fox, skunk, opossum, weasels, fox squirrel, red squirrel, southern flying squirrel, white-footed mice, meadow jumping mice and shrews.

The most conspicuous reptiles and amphibians in the wooded dunes are box turtles; and in the spring Blanding turtles and painted turtles can be found laying eggs in the dunes. American and Fowler's toads can easily be observed in the wooded dunes along with garter snakes, black rat snakes, and eastern hognosed snakes.

A few of the typical invertebrates are digger wasps. antlions, flatbugs, six species of grasshoppers, wireworms and at least one specie of snails. During the summer, deerflies and mosquitoes infest the area.

## Plant Succession

Primary dune succession begins with hardy, specially adapted, pioneer species invading a xerophytic environment characterized by extremely high daytime surface temperatures and by strong winds both of which increase transpiration and evaporation. In contrast, night temperatures may be very low. Dry sand carried by strong winds sandblasts the vegetation making growth and seedling establishment difficult. The surface layer of dry sand serves as an effective insulator, preventing complete dessication of the dune sand. making the growth of vegetation possible. However, during the normal lifetime of most trees, extreme desiccation of the dunes with a consequent die-back of vegetation may occur several times.

The initial invaders on a fresh dune may include marram grass, sand reed, little bluestem and other grasses and herbs like beach pea and lessor Saloman's seal. Common shrubs on young dunes are sand cherry, false heather and juniper; tree species include the cottonwood.

Replacement of the pioneer community by forest is dependent upon soil moisture, nutrient availability and organic matter content which result in numerous successional pathways toward a mesic condition. Often a forest of jack pine with white pine and white birch becomes established. Along the southeastern shore of Lake Michigan the moister climate resulted in the development of a mesic forest of sugar maple, beech and basswood on the old stabilized dunes, particularly on the lee slopes and in pockets.

Southern xeric (black oak) forest has developed on many stabilized Lake Michigan dunes and is the terminal community on the oldest ones. Blueberry and huckleberry often invade the black oak forest as the soils become more acid. Where steep slopes and damp depressions are present, they may be invaded by basswood, which in turn may be followed by a beech-maple mesic forest. Whichever successional route is taken and whatever forest community is the climax about 1000 years appear necessary to reach forest conditions on Lake Michigan dunes.

The relic dune area, lying on the sand plains near Seney, Michigan in the Upper Peninsula, demonstrates a pattern of swale development. There, in wet areas between the dunes, a sphagnum and sedge mat becomes established as peat thickened sedge meadow develop. This community is soon invaded by woody plants like bog birch and leatherleaf. Water seepage across the tilted sand plain results in strips of low shrubs at right angles to the water flow producing a string bog (Olson, 1958).

Plant succession in dune assemblages proceeds very slowly over great periods of time. Obviously, any change imposed on the successional process will likely change the vegetative character of an affected area for an appreciable portion of the 1000 years necessary for reaching a forested condition. Thus, significant long-term changes in vegetation, habitat, species composition, species diversity, and carrying capacity are likely to occur when the process of plant. succession is modified.

## Endangered and Threatened Species

A vital element in the dynamic natural environment of dune assemblages and related shore and beach areas is the special group of species identified as endangered or threatened. Unlike other fauna and flora which may be spacially shifted, or temporarily decreased or increased in number, by a sand dune change, endangered and threatened species may be irreversibly damaged or destroyed by a careless change in the dune environment. For this reason special attention must be given to this vital sand dune element.

### Animal Species

The United States List of Endangered Fauna (U. S. Department of the Interior, Fish and Wildlife Service, 1974) contains the following species native to the Lake Michigan Drainage Basin:

| Family | Scientific Name | Common Name |
|---|---|---|
| Mammals | | |
| Vespertilionidae | *Myotis sodalis* | Indiana bat |
| Canidae | *Canis lupis lycaon* | Eastern timber wolf |
| Felidae | *Felis concolor cougar* | Eastern cougar |
| Birds | | |
| Accipitridae | *Haliaeetus leucocephalus* | Southern bald eagle |
| Falconidae | *Falco perigrinus anatum* | American peregrine falcon |
| Falconidae | *Falco perigrinus tundrius* | Artic peregrine falcon |
| Parulidae | *Dendrioca kirklandii* | Kirtland's (wood) warbler |
| Fishes | | |
| Acipenseridae | *Acipenser brevirostum* | Shortnose sturgeon |
| Salmonidae | *Coregonus alpenae* | Longjaw cisco |

Other species believed to have an endangered status in the basin include the cougar, timber wolf and American peregrine falcon. In addition Michigan lists two mussels [*Simpsoniconcha arnbiguq* and *Obovaria leiben*] as endangered and has designated seven others as threatened, and three as rare. Five insect species are also listed as rare by Michigan. Numerous small mammals will likely be added to endangered or threatened lists.

### Plant Species

Recent lists of endangered and threatened plant species identified 5 endangered and 11 threatened species in the Lake Michigan Drainage Basin (Smithsonian Institution, 1974. This is considered, however, to be a conservative list. Michigan prepared a detailed list of 328 species (Wagner et al. , 1977), of which 40 or 50 percent may occur in the Basin.

This discussion of endangered and threatened species is intended only to illustrate that such species are present in Michigan's sand dune areas and that they must be considered in any evaluation of the dune environment. Current Federal and State lists and regulations will dictate how the presence of endangered species must be treated when encountered in a sand dune area proposed for mining.

## Ecological Factors

Nearly all dune assemblages are characterized by a high degree of exposure to sunlight. The intensity of direct illumination is increased by reflection. The resulting temperatures have a marked effect on the species and variety of flora and fauna which inhabit the dune region because the general exposure of sand dunes to temperature is higher in summer and lower in winter. This great divergence between temperature extremes is further increased by the low specific heat of sand (Cowles, 1899, p. 107). On sandy slopes protected from cold winds, the vegetation renews its activity very early in the spring, because the strong sunlight and the ease with which the surface layers of sand are heated. Willow shoots half-buried in the sand frequently develop a full week in advance of other shoots. Similarly, as reported by Olson. the activity of dune flora ceases early because of the rapid cooling of the superficial layers of sand.

The indirect action of wind produces effects which have considerable impact upon the shoreline ecosystem. Wind plays a prominent part in modifying the plant communities of the dunes. Unprotected vegetation can be destroyed by strong winds through root exposure and sand accumulation.

The soil of the dunes is chiefly quartz sand which has marked peculiarities that strongly effect vegetation. As a rule sandy soils are poor in plant nutrients and do not rapidly develop a rich humus soil because of the rapid oxidation of organic matter.

Vegetation subjected to periods of drought, termed xerophytic flora, are common in the dune environs. Likewise, floras typically adapting to cold, windy locales, such as arctic and alpine plants are also found among the dunes. In situations most exposed to cold winds, one finds the best illustration of the arctic type of plant while the desert or xerophilous type is shown in its purest form on the protected sandy hills (Cowles, 1899).

Dune areas are conspicuous for their diversified topography. This factor determines to a great extent the relation of dunes to water: hills and slopes being much drier than the accompanying depressions. The direction of slope is a matter of importance, the greater exposure of southern slopes to the sun results in drier soil and more xerophytic flora on that side.

Topography accounts for many differences in the rates of deposition-or erosion - and hence in the distribution of indicator species. A typical blowout dune, for example, often reaches down to the water table where erosion rates are slowed and where seedlings of many species, including cottonwoods and willows may be established (Olson, 1953, p. 351). Areas of generally slow erosion may have temporary cover of annuals, such as tumble-weeds or a more permanent cover of sand reed grass which delays the erosion process and encourages deposition. Rates of deposition can sometimes be estimated from the relative proportions of bunchgrass, sand reed and marram grass (Olson) where all are available for being selected according to their most appropriate topographical niches. Thus vegetation not only indicates and regulates dune growth but also provides a record of its history.

Many shorebirds feed at the waters edge. The berms, dunes and over-wash areas behind the dunes serve as nesting grounds for many of them. Active dunes provide homes for various species of chipmunk, woodchuck and fox. White-tail deer, rabbits and weasels graze on the dune grasses and plants (Clark, 1977, p. 96).

## Conclusions

The sand dunes are a living portion of the natural history of Michigan. There exists a delicate balance of factors which maintain and replenish the shifting dunes. The dune system is in equilibrium between the action of two forces. 1) the erosive forces of storm winds and waves and 2) the restorative powers of the prevailing geologic, limnetic and meteorologic action. The dunes play an essential role in the interplay of these natural forces.

If the vegetation is destroyed or the supply of sand altered, whole dunes may dissipate from wind erosion or a reduced supply of beach material. Indicators of dune damage are wind-formed gullies or blowouts, flattened dune crests, wide spread deposition of sand in mature soils, increased local wind velocities and temperature changes, and modified habitat, species composition, species diversity, and carrying capacity.

General impacts on the biological environment are related to changes in the community types and their geographical distribution. Steps for reviewing characteristics of plants and animals for environmental planning and assessment have been suggested by McBride and Canter.

Beach and sand dune communities are well adapted to existence under natural stress but at the same time are fragile if disturbed by development or heavy recreational use. Subjected to frequent wave and wind action, these communities consist of plants and animals especially adapted to colonize beach areas and stabilize dunes. Lake Michigan dunes possess an adapted endemic flora, and, in addition, support a variety of vegetation: northern pine forest, dry xeric (oak) forest and exotic weed communities. Dunes are clearly valuable physical - biologic resources to the shore area of Michigan.

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# III. Environmental Impacts: Physical-Biological Assessment

Based on the concepts and phenomena operating in the dynamic natural environment of Michigan sand dunes in combination with the operational realities of the sand mining industry, certain practical guidelines can be identified to help formulate an assessment methodology.

It is clear, however, that within the context of quantifying impacts of sand dune mining, the state-of-the-art is very limited. Consequently, it would be erroneous and presumptuous to attempt a point-by-point assessment of impact on such specific interests as aesthetic, environmental, economic industrial and agricultural. Instead, it makes more sense to consider the physical-biological group of impacts and derive from that the resulting impact on site-specific features which may be specific forms of agriculture, particular aesthetic features, certain forms of recreation, and specific land uses adjacent to the proposed mining site.

## Assessment Methodology

An overview of assessment methodology suggests that a procedure which identifies potential areas of impact is perhaps the most appropriate method where precise quantification of impact is not possible.

Graphical techniques have been employed with a certain measure of success in identifying particularly fragile segments of the environment and in describing the physical system in an area under study. It has been suggested that future environmental impact assessment efforts, graphical techniques are likely to be most effective as a means of portraying the location and severity of impacts. However, they cannot be relied upon to furnish a quantitative estimate of impact severity or character (Heer and Hagerty, 1977, p. 295). Under some conditions this may still be the best method, given a limited quantitative capability.

A number of other techniques have been developed by various individuals and organizations, in efforts to devise a systematic and universal approach to impact assessment. Matrices have been developed by some individuals with the intention of providing a quantitative assessment tool, yet most have been unsuccessful (Heer and Hagerty, 1977). They are useful, however, for portraying areas of impact.

Checklist methods have also been developed. In this technique a particular project is compared for possible areas of impact with long lists of environmental considerations. A preliminary list is offered in this report. This method serves primarily to ensure that no possible impact is neglected (Canter, 1977).

A number of qualitative evaluative schemes have been developed for environmental assessments. The quantitative nature of these methods indicates that value judgments have been made concerning the importance of particular parameters and the importance of certain degrees of impact by the evaluators.

Thus, any quantitative method can be questioned on the basis that these value judgments may not be appropriate for a particular case under investigation (Heer and Hagerty, 1977, p. 296).

## Considerations for Extractive Industries

Large sand deposits attractive to industry we located within the Michigan dune system and directly offshore. Surface deposits are commonly excavated with transportation costs determining the overall feasibility of the mining operation. Disturbances caused by such extractive activities have significant physical effects on the dune structure--the most severe environmental impact stemming from a reduction in the supply of sand. As previously mentioned, the amount of sand available from glacial deposits, littoral drift and wind activity are directly responsible for dune construction, maintenance and regeneration. The build-up of dunes may take over half a century and the forestation may require 1000 years. It is evident that mining would dramatically affect the ongoing active dune processes, as well as the biological processes, aesthetic appeal, recreational uses, and land uses in the surrounding area.

Any earthwork in and near dune sites would create long term environmental effects. Some important physical impacts include changes in:

- 1. Relief and topographic character
- 2. Width and alignment of material
- 3. Land and water interface
- 4. Geologic surface material (soils)
- 5. Geologic shoreline character
- 6. Land cover
- 7. Beachfront erosion
- 8. Local wind intensity and direction
- 9. Local temperature patterns

Some biological impacts would include:

- 1. Change or disruption in habitat
- 2. Change or disruption in species composition
- 3. Change or disruption in species diversity
- 4. Change or disruption in carrying capacity
- 5. Intrusions on threatened or endangered species

In the case of sand dune mining it is reasonably certain that for every action there is likely to be measurable or observable reaction.

## Evaluation, Methodology and Limitation

In evaluating the ecological consequences of an environmental disturbance it is necessary to examine what changes in the ecosystem would result in significant environmental damage or the potential for such damage. Although types of environmental impacts have been identified and their effects studied to some extent, the methodology for determining the extent of perturbation that can result in significant impact on the ecosystem is flimsy, if not entirely lacking (Sharma, 1975, p. 3).

Significant biological impacts emanate from intricate inter- and intra- species environmental relationships some of which may neither be detectable by conventional biological study nor amenable to statistical treatment (Sharma, p. 5); for example, the multitude of second-order effects that may follow from complete sand removal from an area. A reduced forage base for indigenous animals has an effect on the complete food chain. Such diversity of second-order effects, although emanating from a single first-order effect, are usually not traceable and interpretable in a simple cause-effect relationship and are not amenable to experimental design and treatment with statistical methods.

The significance of biological impacts can further be examined in the context or organism, population and community levels. At the organism level shortening of the life span or death due to an environmental degradation constitutes a significant impact. At the population level, an destruction rate might not be considered significant unless it is great enough to cause a large or continuing decline in population size.

Significant community-level impacts are expected to follow from significant population-level impacts. Major shifts in the relative abundance of a given species can alter inter-and intra-species relationships that have an impact on the community as a whole.

Studies at the organism level provide insight into the mechanisms of damage and species tolerance from a given environmental impact, but population level studies are a must for estimating the number of organisms that may be removed, destroyed or exploited without significantly impacting the population (Sharma, p. 6).

Land use changes also interfere with community types and, in turn, interfere with the individual species within the community.

One way of identifying the multiple impacts of a proposed or existing facility is to implement a checklist approach that includes the potential or real impacts upon various physical features as well as flora and fauna in the area of interest (Canter, 1977).

A list of physical and biological impact criteria is used to identify, describe or measure immediate positive or negative changes as well as the change over time. The resultant environment at some future date should be estimated. Two possibilities in addition to a gross positive or negative change are a "steady state" after a period of time (return to original state after disruption) and a "static state" (an unchanged condition following the original change). A list of potential impacts may be found at the end of the report.

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## IV. Aesthetic Impact Analysis

Aesthetic resources are all resources which cause an observer or receiver to experience a sensory stimulus--whether it be positive or negative. The stimuli detected might be auditory (heard), olfactory (smelled), optical (seen), tactile (felt), or they may be any combination of the four. Of the major human senses it is generally agreed that the visual capacity predominates, providing from 70 to 90 percent of one's total sensory input. Because visual stimulus is of disproportionate importance, and because research on visual resources must differ so profoundly from research on other sensory types, the "aesthetic resource" element of this study will concern itself primarily with visual considerations. Other sensory impact considerations are described in the next section of this report.

### Definition of Terms

In an area of study which is both highly abstract, and extremely subjective, language which conveys clear and understandable images is critical It is important to note that terminology is a continuing problem in aesthetic impact assessment at several levels of analysis. Detailed nomenclature problems will be taken up as they occur throughout this report but it will be useful here to clarify language to be used throughout the visual resource element.

Visual impact assessment appears under a variety of labels in current environmental planning literature. "Landscape evaluation," "landscape assessment," "scenic analysis," and "aesthetic impact," all represent approaches to environmental impact assessment which attempt to deal with visual attributes. While each term does impart some meaning to the concepts of quantifying or qualifying visual resource quality, each variation in language serves to confuse the others. In the interest of seeking a more value-free label in a field already troubled with the complexity of subjective human response, and in an attempt to recognize conceptual differences within aesthetic impact assessment as a whole, the term "visual" resource will be adopted in all further discussion.

## The Background and Significance of Visual Quality

For more than a decade visual resources have been recognized as primary determinants of environmental quality. This recognition was formalized most significantly in the National Environmental Policy Act of 1969 (Public Law 91-190). Though the current statutory significance of visual quality arises principally through the mandate of NEPA, other developments have played an historical part in elevating visual considerations to their present importance. Ross (1975) has summarized the development of visual quality in land use controls with particular reference to coastal zones. The process by which visual amenities have come to be included with other natural resources has been traced by Zube (1973). Finally, the historical development of western aesthetic thought and its incorporation into the planning process is described rather thoroughly by Bagley, et al. (1973).

The importance of visual quality to the individual derives from the idea that people receive psychological benefit from viewing, inhabiting, or otherwise experiencing aesthetically attractive areas (Haskett, 1974, p. 2). Much scholarly research points to the conclusion that perception is an integral part of individual and group dynamics. Perception has been linked with the cognitive, affective and behavioral functioning of people (Ross, 1975, p. 1). Arnheim (1969) contends that reasoning is not possible without perceptual stimuli. Tuan expresses the importance of a beautiful landscape which " . . . like any aesthetic object, has the power to express through purely visual means . . the forms of our feelings. " (Lewis, et al. , 1973, p. 27). Rosow (1961) suggests, as have others, that the sensuous environment affects the texture of social interaction. Other scholars have expressed the need for aesthetic stimuli generally in philosophical terms.

In a more empirical fashion, people often demonstrate their evaluation of visual resources in marketplace decisions. Choice of residence sometimes reflects aesthetic judgements as in the case of persons who have been found to be willing to pay two to four times as much for waterfront lots with extended views over water as for interior lots. Similarly, location choices by many segments of business and industry indicate an increasing sensitivity to aesthetic factors (Ross, 1974, p. 2).

## The Conceptual Basis of Visual Quality Assessment

Evaluation of visual quality may be characterized by its complexity. The central concept addresses several rudimentary questions: What is visual quality? Which landscapes have what sort of visual quality? What contributes to visual quality?

Visual quality is both ephemeral and intangible. On first examination it would seem to defy description or definition though methods for measurement have been devised. In addition to the complexity posed by the above questions, there are three important sources of variability which act to further complicate visual assessment.

1. Historically, visual values have not remained constant but have changed through time (Johnson and Huff, 1966, p. 9). Research indicates that, currently, natural landscapes are often considered more aesthetically pleasing than man-dominated ones though this is an exception when viewed in the context of the entire history of landscape taste (Lowinthal, 1962). Also, standards of measurement used for judging aesthetic quality differ according to the degree of human influence found in the environment regardless of whether the individual prefers naturalistic or man-dominated landscapes.

2. Visual quality also varies with the individual experiencing the stimulus. Not all persons perceive the same landscape in the same manner nor do they assign to it the same value.

3. Perception of visual quality may vary for any one individual. One's perception of the same landscape may differ according to the time and circumstances of each exposure. Though a view might be valued greatly at one time, ones psyche or local conditions nay intervene to cause one to value the same view differently at another time or under other circumstances. There is also the possibility that sequential exposures cause still further variability in ones perceptions.

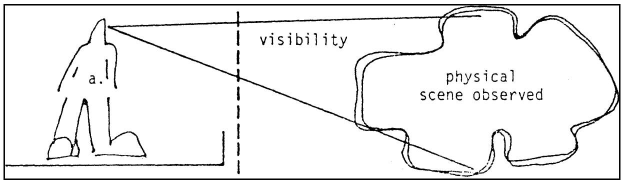
To summarize, the problem of multiple perceptions in combination with innumerable physical inputs, and the elusive nature of those factors relating to the observers psyche, act to substantially complicate the conceptual aspects of assessing visual quality.

Visual quality consists not only of factors relating to the observers psyche and his role as observer, but also to those factors which comprise the character of the physical scene and to the visibility of the scene from the observer's perspective (Haskett, 1975). The physical environment and the relative degree or direction of visibility lend themselves more readily to quantification than the more elusive psychological factors described earlier. For the resource manager's purposes, given current capabilities, measurement of physical parameters holds more promise for practical and effective measurement of visual amenities. The following list and figure are useful in demonstrating the manner in which the basic visual quality components may be categorized.

1. visual components
- a. physical scene
- b. visibility of scene from observer's perspective

2. psycho-dynamic components
- a. disposition of the observer (internal factors)
- environmental disposition (attitudes, beliefs, and values)
- physical composition (age, sex, health, etc. )
- motivation and purpose (reason for presence at time and place)
- b. environmental setting of observation

- climatic and temporal factors (sun, wind, temp. season, time)
- sensory inputs (sound, taste, feelings)
- Figure 1 b. 1. psycho-dynamic components 2. visual components




(After Haskett, 1975, p. 5)

As may be seen in the figure, those attributes characteristic of the viewers setting and disposition are termed psycho-dynamic components and are differentiated from the more remote physical scene and its visibility, which comprise the visual components. The former constitutes the receptor and its state, while the latter constitutes the visual message and its source.

The preceding list and the accompanying figure describe succinctly the components of any visual quality consideration and the relationships between the parts. The important implication of this is that the visual set of components is the more easily measured of the two, though the psycho-dynamic also has its place in any rigorous assessment of visual resources.

## Visual Quality Assessment Methodologies

Several research works have been completed which inventory and compare the characteristics of a broad range of visual resource studies carried out prior to 1976. Viohl (1975) compares 33 studies and methodologies for evaluating visual quality. It is of interest that one study among the 33 concerns itself specifically with the visual quality of sand dunes. Mann and Associates (1975) review a lesser number of visual resource studies but analyze and compare each in more detail. Both of the above studies are well suited to further research needs in that each emphasizes coastal zone planning.

A review of studies concerned with the assessment of visual quality suggests that there are two general approaches to the problem (Viohl , 1975, p. 2). The first is the perception or preference study which deals with the nature of man's perception, interpretation and subsequent preference for his visual environment. These studies have in the past been the province of the psychologist. Perception/preference studies may be further categorized as to whether they are concerned with a) understanding the nature of man's perception or with b) simply gauging observer preferences.

The second type is the descriptive inventory which is the more common means of representing and evaluating landscape quality. Of the 33 case studies reviewed by Viohl (1975), 22 were of this type. They range in sophistication from subjective lists of descriptors or checklists of visual attributes to methods of weighting or ranking landscape dimensions.

These two basic methods of visual assessment and the optimal techniques currently in use for each, are diagramed on page 47. The perception/preference studies and the descriptive inventory study may be seen to correspond respectively to the psycho-dynamic and visual components of the visual quality concept as it has been previously described.

Figure 2

## Studies in Visual Quality

(1) Perception/Preferences Studies

- a) Conceptual Investigations
  - *ranked photographs*
  - *semantic differential*
  - *pupillometrics*
  - *thematic apperception tests*
- b) Preference surveys and Questionnaires
  - *relative demand function*
  - *user participation rates*

(2) Descriptive Inventories

- photographic data
- cartographic data
- professional field observation and evaluation

(After Viohl, 1975, p. 2)

Characteristics of the physical landscape which influence visual quality have been categorized by researchers in various ways. Despite confusion in terminology it may be said that there generally are three categories of characteristics influencing visual quality: One, landscape elements which refer to the physical features of the environment which lie along a continuum ranging from the natural to the man-made and which can be measured by standard scientific means; two, landscape properties which are descriptive attributes of landscape elements, and which can be scientifically described; three, landscape dimensions which represent observed relationships between elements and properties and which are less easily quantified (Viohl, 1975, p. 3).

Following is a list identifying many of the visual elements, properties, and dimensions commonly found in the current literature.

## Landscape Elements

- land forms topography! relief/slope shoreline forms land use
- water forms vegetative forms
- man-made objects (structures/structural groups/paved surfaces)
- Properties of Landscape Elements
- Scale (height, width, depth)
- color
- texture
- edge definition

- degree of pollution evident
- degree of naturalness
- degree of urbanization

## Dimensions of Landscape Elements

- complexity / variety uniqueness / novelty / contrast naturalness
- urbanization pollution unity / harmony / order / compatibility / coherence disharmony / misfit pattern / sequence
- movement! rhythm surprise / mystery
- character types / regional identity
- view characteristics: enframement, enclosure, focal point, observer position, direction scenic 'beauty"

(After Haskett, 1975, and Viohl, 1975)

A number of positive trends may be seen in recent visual assessment methodologies: First, more utilization is being made of modern data gathering and handling techniques such as computerized data processing, remote sensing techniques, and psychometric scaling methods; second, terminology appears to be moving toward greater uniformity and therefore, greater clarity; third, more studies are being performed on a genuinely multidisciplinary basis, incorporating combined professional and lay judgment in their decision making process.

## Criteria for the Selection of Visual Resource Assessment Techniques

Additional research must be devoted to the task of designing a specific visual quality assessment technique appropriate to the circumstance of sand mining in Michigan's coastal sand dunes. To this end, the following general criteria are suggested for visual assessment models as formulated by Roy Mann Associates (1975).

Scale:Applicability of the method to a range of landscape scales, i. e. , site-local-regional.

Universality : Applicability of the method to a variety of geographical conditions and aesthetic resource attributes.

## Implementation Requirements:

a) Need for specially trained personnel and outside expertise;

b) need for specialized equipment; computer facilities and sophisticated data collection, processing and analysis techniques.

Systematicness: Applicability and validity of the theoretical basis of the method; ease with which the method can be applied.

Flexibility: Compatibility of the method with other planning program elements.

Relevance of the Method to Program Objectives:

a) Determining permissible uses;
b) Designating areas of particular concern;
c) Assessing aesthetic resource impacts;
d) Determining priorities to use.

More specific criteria, which are also applicable to visual assessment of sand mining, are those specified in a preliminary study formulated for an inventory of visual quality assessment in New York's coastal zone. Felleman, 1975). Following are the principal criteria specified for visual resource analysis;

Use of a nested hierarchy of scales (land resource or geomorphic units) relying on initial large scale groupings of topographical features and shoreline configurations.

- Sampling and testing of methods to ensure shore zone features are clearly differentiated (resource analysis) and accurately communicated (data collection and recording).
- Use of geomorphic terms where feasible to provide direct linkage to erosion and development analysis.
- Establishment of a comprehensive system by including both;
- a) offshore, beach, bluff and upland components
- b) embayment - enclosure relationship analysis

A reliable, responsible method of scenic resource analysis is critical to the informed analysis of sand mining impact, though any selection from existing visual impact assessment methods will necessarily depend largely upon the evaluator's objectives, time, resources and skills.

Note - given the high cost arid complexity of visual resource assessment and the importance of uniformity and large scale data collection methods, can these techniques be part of an impact statement system wherein the burden of providing data and analysis is on the mine owner? It is suggested that the above expectation may be unrealistic and that visual resource assessment must be integrated with the assessment of other physical resources by the Department of Natural Resources. Section VII incorporates aesthetic criteria into a system of impact assessment.

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# V. Socio-Economic Impact Analysis

There has been, in recent times, . . . a deepening concern for the people impacts' associated with development planning throughout the country and the world' (Wolf, 1975, p. 259). This concern has resulted from a host of factors ranging from what some call "people pollution;" the inevitable pressures of a prodigious population, to what others would call technological progress, the non-human and often inhumane result of man's "work. "

The following describes socio-economic impact assessment: a newly emerging field of interdisciplinary social science knowledge and application. Its aim is to predict and evaluate the social and economic effects of a policy, program, or project while still in the planning stage--before those effects have occurred.

## Definition of socio-economic Impact Assessment

Despite a thread of unity running through the literature as a whole, there is come superficial diversity in definition of social impact. Definitions range from those which predicate social impact upon simple technological changes to those which allude to a causal complexity so subtle it only permits approximation. They also differ as a function of the nature of the change-producing project in question.

Following are examples from the recent literature defining social impacts as:

responses of social systems to the physical restructuring of their environments. By implication, then, social impacts involve adaptations on the part of social systems to 'external' agents of change. " (Shields, 1975, p. 2-5).

changes in local society and culture, . . . [that con] be classed as 'benefits or 'cost' according to whether they decrease or increase tensions and stresses among the human population. " (Drukcer and Philip, et al. , 1973).

"All changes in the structure and functioning of patterned social ordering that occur in conjunction with an environmental, technological or social innovation, or alteration. Impacts are dynamic processes . . . and therefore must be continually measured through time. (Olsen and Merwin, 1976, p. 4).

"Any significant improvement or deterioration in people's wellbeing (synonymous with 'quality of life') or any significant change in on aspect of community concern. ' (Duncan and Jones, 1976).

"Impacts on people and communities other than those which operate primarily via the dollars in their wallets. " (Glickfeld, et al. [After R. Mack] 1978, p. 72).

Others have tried to define social impact assessment. These descriptions build on definitions of impact such as those above, but often expand the scope of concern. Below are examples from some of the principal literature defining social assessment as: -

the identification, analysis and evaluation of a social impact resulting from a particular event, or the comparisons of two or more futures over time. " (Duncan and Jones, 1976, p. 8).

understanding of how different individuals, groups, organizations, institutions and whole societies behave in their environment, and how they do or don't adapt when change is introduced in that environment. " (Glickfeld, Whitney and Grigsby, 1978, p. 3).

clarification of the social and human meaning of the consequences of projects, programs and technologies that our apparently short-sighted forethought is creating. ” (Peterson and Gemmell, 1975, p. 374).

A more complicated, and perhaps more complete definition of socioeconomic impact assessment is offered by C. P. Wolf (1974, P. 2-3), one of the field’s keys exponents. Wolf addresses the question, “What is SIA?” (Social Impact Assessment), at four analytical levels:

“Operationally, it can be designated as final compliance with legislative acts by analogy with the environmental impact assessment required -by . . , the National Environmental Policy Act of 1969 (NEPA). ” at the most general level, . . . a problem of estimating and appraising the condition of a society organized and changed by large-scale applications of high technology. ”

“Situationally, . . . [as] a procedure for anticipating, in Merton’s (1936) phrase, ‘the unanticipated consequences of purposive social action,’ and thereby to forestall or offset adverse effects to which it may give rise. SIA is in this sense a hedge against uncertainty in the planning process,”

However one defines the assessment (measurement, description, or knowledge) of socio-economic impacts, they may be regarded as changes; arising from any sort of environmental alteration (projects, programs, or technologies); experienced by any segment of the population (individuals, groups, organizations, or institutions); being of form and significance which varies with the characteristics of each population segment and with the differentiation within the society as a whole.

## Background and Significance of Social Impact Assessment

Unfortunately, the identification of environmental impacts and their causes is difficult at best, and in the Case of social phenomena, the difficulty is made additionally complex. - In their description of the enormity of this problem, Peterson and Gernmell (1977, p. 374) state: *“In the process of our accumulation of wealth-producing tools and machines, we have accumulated social and environmental complexity that may already have exceeded the capability of our forethought. ”*

The authors explain further; *“For every action taken in the name of social progress there is an intricate cascade of reactions, and a price tag for someone or some group. ”*

The relationship of man to technology and induced environmental change, in a social sense, is perhaps most succinctly outlined by C. P. Wolf (1974, p. 3) in his description of the “curious transposition” by which culture has come to dominate nature:

The problem of social impact assessment is not so much what we are doing to the environment; it is what we are doing to ourselves through the medium of environment by technological misapplications.

These and other events have led to an outgrowth from many branches of social science that are attempting to embrace the demands of environmental impact assessment generally, to come to terms with human quality of life in a meaningful way.

As with other categories of impact, social assessment became formalized as a result of federal legislation although there is disagreement on the strength of this relationship. The National Environmental Policy Act of 1969 (NEPA) does declare a “policy which will encourage productive and enjoyable harmony between man and his environment and stimulate the health and welfare of man . . . “ but some would argue that this is a weak legal rationale, dependent largely on interpretation. Others have maintained that social impacts are central to the environmental impact analysis process and that portions of NEPA indicate that it is intended to be oriented to the social as well as the physical environment. Wolf (1975), in writing on “Socially Oriented Impact Statements,” has insisted that the broadly defined portions of NEPA together with individual agency guidelines (CEQ, and others) constitute a “charter, if not an outright mandate to anticipate and examine social impacts. ” Whether its true status is implied or expressed within NEPA, social assessment became an organized field or inquiry at its inception.

The very limited history of social impact assessment proceeding NEPA has been outlined briefly by Wolf (1974, p. 16) in his description of Federal interest in SIA. The ‘tenured member,’ as Wolf puts it, is the Federal Highway Administration (actually -the old Bureau of Public Roads) whose ‘Social Impact Programs “. . . was advertised as ‘top priority research’ as early as 1966. ” He notes that though the effort faltered badly after its auspicious beginning, it has since been revived. Other significant SIA programs have come into existence under the direct sponsorship or the indirect influence of NEPA.

The significance of social impact assessment lies in the fact that “The word ‘environment’ means much more than physical things; most assessment efforts at least attempt to be concerned with social, economic, political, and human things as well as conditions of air, water, and land. ” (Peterson and Gemmell, 1977, p. 374). Of transcendent importance, however, are the implications of social impact assessment. ” Above all, . . “ says Wolf (1974, p. 4 “ . . . what SIA symbolizes is the assumption of social responsibility on the part of public authorities and its imposition on private interests. ”

## Conceptual Basis of Social Impact Assessment

In simple terms social impact assessment is based on the need to account for those things that are often regarded (or disregarded) as the "political* battles” which may rage over certain impacting issues. The term political must be used loosely here but what is essential in its meaning is the reference to a broad range of concerns which may lack a proper forum for intelligent understanding. Canter (1977, p. 164) has characterized past socio-economic conceptualization as a “. . . Catchall group . . . ;“ “. A composite of numerous interrelated and nonrelated items . . . “. Others have concurred with this judgment. Wolf (1974, p. 12) speaks to this point saying “General definitions have tended to be residual--’non-market,’ non-biological,’ whatever is left after more definable entities and quantities have been deducted. ” Social impact assessment, viewed more optimistically, is the concept which attempts to provide a theoretical framework within which diverse individual concerns may be understood rather than deposited.

The theoretical and empirical support for social impact assessment comes from the behavioral sciences. It is thought that the disciplines of sociology, political science, economics, psychology and anthropology will,

*Political matters are defined here as those which deal with ideological problems as opposed to technical matters or those which are concerned with known or knowable facts (Peterson and Gemmell, 1977, p. 377).

With increasing accuracy, reliability and convenience, be able to provide an understanding of how different individuals, groups, organizations, institutions and whole societies behave in their environment and how they react to change. Specific theory has emerged primarily from basic conceptualizations of human experience known variously as “social well being” or ‘the quality of life. ” Traditionally, theory of this type has been organized in the form of a continuum (or hierarchy) of human needs or wants ranging from elemental factors of survival to those which might constitute elements of free choice or “luxury. ” Principal examples include Abraham Maslow’s “Hierarchy” [1954], and Harold Lasswell’s “Taxonomy of human needs and wants” [1971]. It is sufficient here to describe only the nature of these concerns and their central position in the effort to make explicit those things which are implicit in human life. Full descriptions of these concepts and their employment are offered later in this section.

It is useful to remember that in addition to the above theoretical basis, SIA is contingent ultimately upon “. . . Two logical premises: (1)that the future (or alternative futures) can be predicted, and (2) that those who are concerned about alternative futures in the context of a proposed project or technology will understand the assessment and respond by modifying the decisions they might otherwise have made” (Peterson, and Gemmell, 1977, p. 374).

## A Review of the SIA Literature

Systematic work in the field of Social. Impact Assessment dates almost exclusively from the period following the passage of the National Environmental Policy Act (1969). Being of such recent origin; the interest may properly be regarded as embryonic in its stage of development. “To all appearances

,“ says Wolf (1974, p. 13), “ . . . Social Impact Assessment is still in the ‘natural history’ stage of science-building [case study approach], at a point far removed from the mature stage of deductively formulated

theory. ” Wolf’s evaluation has been qualified in more recent work as “ . an excellent guideline to where SIA was in 1974,” though it is still largely accurate. Peterson and Genrnell (1977, p. 375) have confirmed the status of SIA in a concise manner as “deficient,” not being one of simply applying known theories and valid methods to specific cases.

Though it is expanding rapidly, relatively few attempts have been made to digest and organize in an analytical sense the body of literature devoted or applicable to social impact assessment.

Wolf (whose account of the genesis of SIA was cited earlier) edited a compendium of articles which initiated the formalization of methods, techniques and theory in the Environmental Design and Research Association’s volume of 1974 on Social Impact Assessment. This approach was expanded and updated in a State-of-the-art examination by Finsterbusch and Wolf in the Methodology of Social Impact Assessment (1977).

A second approach to assessing the state-of-the-art of SIA has been that of the analytical bibliography characterized by Shields in his description of “Grounded Theory” (1977, p. 64) as the best possible means of “mining” the literature. First among the attempts to investigate SIA via such an organized bibliography was Llewellyn (1973) who analyzed and catalogued over 300 publications dealing with social impacts of highway construction. Following this lead and further refining the technique for application of SIA was Shields’ own work;. . Social Impact Assessment: An Analytic Bibliography (1973) which sought to comprehensively inventory the literature bearing upon social impact assessment generally. Shields employed the technique of expository analysis, drawing conclusions on the state-of-the-art within six impact categories (demographic impacts, institutional impacts, displacement and relocation, economic impacts, community cohesion, and lifestyle) and on a variety of methodological considerations.

Most recent among efforts to compile bibliographic analyses of SIA literature was that sponsored by Stanford University (Glickfeld, et al. , 1978) entitled A Selective Analytical Bibliography for Social Impact Assessment. In this work, the authors have attempted to identify useful types of information and to “. . . monitor the state-of-the-art in SIA practice, and research and development. ”

The following description is drawn exclusively from the findings of this work. It is the most recent and complete source.

The body of literature devoted to SIA has been divided by Glickfeld and her colleagues into four categorical types which are described below together with summaries of the author’s conclusions.

1. The behavioral science literature as a source for theory and empirical evidence to give substantial knowledge to social impact assessment efforts.

The authors admit sketchy coverage of the literature attributing this to the enormity of the technical problem at hand; “it is more than one person s life’s work to link together the theoretical bases of several separate disciplines and cross-catalogue the findings of empirical studies in these disciplines so they can be reasonably assessed . . . " The authors conclude that, despite the seemingly overwhelming nature of the task, and contrary to others who have concluded that new theory should be developed instead, "It is time for academic behavioral scientists to work on operationalizing theory, and reorganizing empirical findings into a substantial knowledge resource. "

2. Post-evaluative case studies where impacts had been evaluated after some induced environmental change.

Those who doubt the feasibility or the utility of looking into the behavioral science literature for the knowledge necessary to apply SIA, are those most optimistic about post-change impact evaluation. This approach assumes that if other things are controlled for, social impacts can be predicted from past experience in similar situations. These sort of studies have been found to be very rare. The authors offer two reasons which might explain this scarcity. First, past experience is lacking because social programs and services (as opposed to physical! economic projects) have seldom been required to make predictive analyses. Instead, the human services arena has concentrated on program evaluation but unfortunately, has not examined unintended effects--the critical element in SIA. Secondly, post-evaluative studies tend to be longitudinal in nature; that is, they tend to require greater resources in order to monitor a single project through long periods of time.

3. The "SIA" literature which focuses on definitions of, justification for, and methodology involved in social impact assessments.

The SIA literature arises from a vast array of sources and within a wide range of topics. The list below typifies the sorts of state-of-the-art papers that were reviewed.

1. Definitions of SIA
2. Identifications of key impacts of particular activities in particular environments
3. Identification of existing tools
4. Development of new tools
5. Development of routinized procedures for performing SIA
6. Identification of methods to integrate SIA with other planning or decision-making efforts

Results indicate that few individual efforts involve all these topics. It is significant that despite these differences in substance, the similarity in definitions, tools, and checklists was surprisingly high. This consistency points to some consensus regarding needs and methods, but also suggests some duplication and perhaps less than desirable allocation of resources within SA research.

4. Case studies where social impact assessment has been used for prediction of planning.

Predictive studies were found to exhibit several characteristics; first, they ". . . tend to be concentrated in areas where they are required by Federal or State law," and secondly most tend to be called socio-economic studies

though they are " . . heavy on the economics and light on the social. " It is generally agreed that the majority of predictive studies are of poor quality both because of

serious epistemological and methodological complexities" and because of a poor information transfer system which fails to get available knowledge to those who need it.

Critical analysis, future directions and trends, and additional research needs will be dealt with in more detail in the next parts of this section.

## Methodologies for Social Impact Assessment

The following is a description of salient methodological considerations organized to proceed from general concepts to more specific alternative methods and techniques (see Figure 4. ). It has been based upon literature surveys and represents more conventional approaches, though other combinations may be considered appropriate depending upon resources and needs.

Among those who have postulated models upon which social impact assessment might be built, it is generally agreed that Baur' s "interactive approach" offers the best framework for the analytic problems of social impact assessment. Baur provides the following rationale: "Instead of assuming that the social effect is the result of a specific cause or chain of causes that are traced to a-. technological innovation, I propose that we think of an effect as the outcome in the form of altered human conduct of the interaction between the agents of change and the people who have an interest in the proposed public works project. " What is described then, is a two-directional or multidirectional causal flow; one in which social factors are as much the cause of social impact as they are the effects. Wolf (1974, p. 10) has clarified the complications of this interactivity in pointing out that ". . . in no case can the impact be considered a 'point event'; rather, the effects linger and intermingle with others appearing later. " Figure 3 presents Wolfe's (1974, p. 11) model illustrating the causal complexity of social impact assessment as an open, dynamic system. The basic utility of the interactive approach is that it attempts to "derisidualize" or "detrivialize" social impacts, promoting them from dismissal as "secondary impact" to a position of causal importance. The importance of such an interactive approach cannot be emphasized too much.

Direct impacts of the project [1] represent deviations from pre-project conditions described by base line data ("Profile"). Second order impacts then "feed forward" illustrating reaction through readjustment or adaptive change [2]. Conversely, a "reaction formation" may be encountered in the planning phase by which project opposition modifys project plans [3]. Project identity is determined in part by pre-existing circumstances or prior situations in the affected area [4] which continue to affect public attitudes at the points of impact and adaptation [5]. Finally, consequences of the project (impact and adaptation) are additionally influenced by external forces [6].

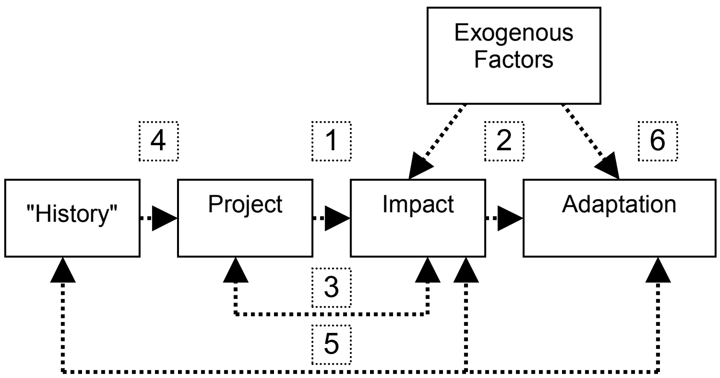


*Figure 3. Interaction of Factors Through Time in Social Impact Assessment.*

*Figure 4 Progression from theory to practice in social impact assessment - not included here. See Wolf, 1974 Glickfield 1978 and/or Finsterbusch 1977 for details.*

Following the selection of a framework within which SIA may be placed, the problem immediately arises of how to choose meaningful sets of variables from the entire universe of potential impact parameters. Three principal methods have evolved through efforts to explore different content categories for useful impact descriptors. The most obvious of these methods are the deductive and inductive approaches. The deductive approach calls for an original concept, its conversion to a variable, the hypothesizing of a relationship between variables to achieve a theoretical formulation, then the development of referents (indicators and measurement techniques by which may be determined the direction and strength of the association. Clearly, such an approach is rational in the extreme and for that reason is seldom used. The reader will recall that SIA has been described as still in the “natural history” stage - a considerably more primitive state than that of the deductive model above.

The converse approach of inductive analysis is felt to be the more fitting method but because it tends to simplify, it has been thought to be potentially stagnating to social impact assessment.

In the need for a method which is not “ultra-rational” and one which at the same time would build a cumulative knowledge base, a third approach has been proposed. Wolf and others have suggested a combination of the two methods of inquiry; a mixture termed “analytic induction” which would lend itself to a simultaneous examination of the particulars of a given event and those things which are general and theoretical. The inductive approach is admitted to fall short of shedding great light on theoretical linkages but despite its “causal ignorance” it has the critical virtue of “legitimizing variables that are not included in the current systems of economic accounting. ” (Wolf, 1974, p. 13).

Selection of a theoretical framework allows the researcher to proceed to applications of social impact assessment concepts. As mentioned previously in the review of social impact literature, two approaches predominate

among case studies which qualify as assessments of social impact: (1) ‘post evaluative approaches, and (2) predictive approaches.

Application of SIA concepts to post evaluative examination of social change has as its premise the assumption that “ . . . if cultural and environmental differences are controlled for, social impacts can be predicted from past experience in similar situations. ” (Glickfeld, 1978, p. 4). It follows then, that the more comprehensive the knowledge base (the more findings that are accumulated from a group of similar situations, e. g. sand mining operations), the more substantial is the base upon which a theory of social impacts may be built. Emphasis on “past performance” makes this approach most attractive to those who prefer an empirical match to the more elusive task of seeking theoretical linkages within the knowledge of the behavioral sciences. Actual applications of this approach were found to be rare.

Predictive applications of SIA concepts differed according to the findings of Glickfeld, in the sense that they were “project specific” and did not seek to apply the conclusions of general sets of observations to similar circumstances. Secondly, whereas post evaluative approaches tend to fall within the domain of “human services,” predictive applications tend to fall within the domain of physical development. Also, they tend to minimize social factors and to emphasize economic factors though both are most commonly located under the shared term socio-economic impact analyses.

Although the predictive study was found to be the more frequently employed methodological approach, most case-studies were found to be inadequate both in terms of their theoretical foundation and their analytical balance. Glickfeld and others have concluded that these deficiencies arise for five principal reasons:

1. lack of theoretical understanding on the part of those executing the study;
2. lack of time and financial resources;
3. the politically threatening nature of social impact assessment;
4. the serious epistemological and methodological complexities involved (current limitations of the social . sciences);
5. a poor information transfer system which fails to deliver knowledge to those who might apply it.

The above descriptions, though brief, are sufficient to describe the differences and limitations of both approaches and their positions relative to other concepts in social impact assessment. It should also be noted that the approaches described represent only convenient categories for analysis of trends; they ?re not operational definitions.

The preceding discussion of theoretical considerations serves only as a framework for social impact assessment; lacking the inputs which, when examined, -can provide the basis for decisions regarding social change. Following is a brief state-of-the-art description of the methodological steps which are thought to best provide this data and the interpretive mechanism for determining social impact.

It is generally agreed that a hard and fast system is lacking for applying theoretical concepts to the problem of assessing social impact. Clearly, while agreement is lacking on the means of selecting factors from the constellation of social attributes, and until models of social systems become substantially refined, there can be no step-wise procedure which may be generally applied to yield highly reliable predictions of social consequences.

Yet, despite the absence of a specific sequential procedure, there appears to be consensus on four broadly defined "steps" which describe the basic analytic processes at play in the practice of social impact assessment. Each of these four steps draw upon a range of specific techniques and methods familiar to the social sciences.

1. Profiling, is the process of making an initial description of the study area or impact situation. It provides the baseline social data by which both intended and unintended social changes may be estimated. Essentially it is the "before" measure of social conditions which when compared to the "after" conditions induced by a given action, or inaction, yields the amount and type of social impact felt by groups and individuals. The sets of profile features or social factors on which data are gathered in the course of profiling comprise the categories of impact used in later assessment stages (Finsterbusch and Wolf, 1977, p. 153).

Wolf (1974, p. 22) has pointed out two problems which "intrude" at the profiling stage: (1) defining the area which may be impacted and (2) determining data points which clearly describe the social system. He suggests that two approaches may be taken toward the problem of delimiting the impact area. The "project-related" approach assumes the existence of a project plan which specifies the areal limits of project alterations theoretically limiting the causative factors, and hence the predictable impacts. A more realistic and also more difficult approach is an area-related" one. Such an approach is less well specified but affords consideration of a wide-range of social conditions and planning possibilities. The former does not reach beyond a set of impacts considered in relative isolation whereas the latter seeks to address the critical dimension of social impact assessment--the social system as a pre existing whole. The second problem, that of determining accurate data points, reflects back on the problem of selecting wisely from the universe of social characteristics but it also has implications for data collection methods. Measures such as "types of social uses" and "social orientation" are not easily made, and consequently they require "proxy" mechanisms such as those which may be provided by census and other tabular data. The critical element here is the creative ability of the researcher to devise indicator sets which will lend accurate dimension to social impacts.

A broad range of techniques are available for social profiling with choice depending upon user needs and the theoretical framework within which they will be imbedded. Wolf (1974, p. 21) has provided a list of examples which can be expanded and subdivided but is included here only for illustrative purposes (see Figure 4; "available techniques"). Other techniques are available but strict guidelines do not exist for the application. Few of the techniques which may be found useful represent significant departures from conventional social research.

Lists of sources for social profile data have been developed and are useful in determining staff costs, expertise and limitations as well as assisting in the collection of hard data. Two such lists appear in Wolf's (1974, p. 23) "Community Profile-Census Data and Sources" and Aidala's article on "Computer-assisted Social Profiling" in Finsterbusch and Wolf (1977, pp. 167-171).

2. Projecting represents the second broad step in assessment. It involves the forecasting of future impact situations and is among the most difficult of SIA operations, requiring a broad range of analytical operations and the use of a wide variety of research tools and techniques. Projecting is a crucial step because policy decisions must be made on the comparison of a predicted state of affairs "with and without" the consequences of a proposed action.

The obvious problem in "prediction" is that the criteria by which present actions are judged in the future will themselves inevitably change. Wolf (1974, p. 25) explains the role of this constant flux in the words of Eigerman [1973], another SIA researcher who observes; "everything changes whether a given plan is implemented or not. Therefore, plan-induced change is not the difference between what is forecast 'with' a plan and some stead-state 'today'. It is the difference between two forecasts: what is anticipated 'with' the plan and what is anticipated 'without' it. "

Any detailed discussion of projecting would at this time necessitate a full state-of-the-art description of alternative future forecasting: a task well beyond the scope of this report. It is sufficient to note that at present a large number of techniques exist for projecting, and others are being introduced to meet new demands. Finsterbusch and Wolf (1977, p. 200), who describe the state-of-the-art fully in the Methodology of Social Impact Assessment, summarize, saying; "The array of techniques indicates both impressive achievement and monumental challenges. " A list of the main techniques for prediction may be found in Figure 2. This list has been drawn from a concise review of available techniques titled 'Methods for Estimating Societal Future" in Finsterbusch and Wolf (1977, p. ?02).

3. As may be apparent to the reader, nomenclature does not clarify entirely at first reading the differences between SIA concepts. There is some overlap between categories and procedures in terms of both concept and material. This is in keeping with SIA's stage of development and the familiarity of all but the fully informed reader. Assessment would seem to involve much of the same activity as was described in projection yet there are important differences. "Logically, the 'assessment' step means solving the difference equation between profile projections 'with and

without' a planned intervention. Actually, a good deal of what may be construed as assessment takes place independent of formal projections" (Finsterbusch and Wolf, 1977, p. 263). The operation of assessment is one of identifying significant impacts. This is not, as was stressed above, the simple operation of subtracting the "without project" state from the "with project" state to yield potential impacts. Rather, the situation of assessment is a loaded one, with inherent qualities and limitations. "The criteria of significance . . . " says Wolf (1974, p. 26) " . . . are already preconceived in the categories of effect that enter the profiling step, and are predetermined in those of cause that initiated the study. Moreover, the net balance of effects can only be measured in [the assessment step], not weighed in comparative judgment until evaluative factors [the evaluative step] come into focus. What is sought in this step is an objective appraisal of impact magnitudes, without fear or favor" (emphasis added). Even when reduced to the purpose of dispassionate analysis, assessment remains difficult. Paramount among the problems in assessment is the researcher's ability to regulate those values which are assumed by the experimental variables, both independent and control. The range of experimental controls an assessor can exercise over independent and dependent variables is given in the available mix and choice of planning alternatives but the use of hypothetical values, uncorrected by the use of empirical controls soon stretches credibility. In view of the interactive nature of social impacts, the experimental validity of predicting indirect consequences in the absence of empirical controls breaks down after second order effects. It may safely be concluded that many of the methodological problems owing to the analytic complexity of the interactive approach remain overwhelming and thus unresolved.

Methods and techniques of social research which have application to impact assessment are unlimited and often conventional. They are drawn from the entire collection of measurement techniques in the social sciences to meet a variety of purposes. Because space does not allow a listing of methods and techniques the reader is referred to the many texts on social research methods for a complete enumeration.

Assessment procedures offer fertile ground for innovative techniques of social measurement, and it is with examples of such "new" techniques that reviewers of SIA literature commonly limit themselves. Principal among these are Finsterbusch and Wolf (1977, pp. 265-313), who have included a variety of novel techniques by contributing researchers ranging from experimental surveys to content analysis of historical records.

4. Last among the broad procedures which make up social impact assessment is that of evaluation. This is the process of selecting from among the dispassionate appraisals of impact which have been generated in the assessment step, with the objective of making decisions which will increase net social benefits and decrease social costs. The evaluation step is a departure from previous SIA procedures in that it " . . . goes public . . [by] . the attaching of values and assigning of weights as to the desirability or undesirability of the impacts assessed . . . " (Wolf, 1974, p. 27). Thus, breaking with the norm of technical neutrality which should characterize all previous operations.

Unfortunately, impact evaluation remains extremely difficult because it requires that choices be made through the comparison of unlike variables and because "a satisfactory medium of exchange which can be used to compare social utilities for non-market values is not currently available" (Finsterbusch and Wolf, 1977, p. 314). As a consequence of this profound yet unresolved problem, it is the current practice either not to rank social factors relative to each other, or to ask some group, sample of citizens, or planner to weigh them.

Much of the difficulty remains, however, even with recourse to public involvement and/or expert opinion due to qualities inherent in human perception. "As an analytical task, impact evaluation is based on values and is inevitably subjective" (Finsterbusch and Wolf, 1977, p. 314). Social impact evaluators whether they be citizen or expert individuals, may identify better and worse alternative policies, but they can only do so in a subjective manner, that is to say, they must be based on someone's definition of "better" and "worse": It is important to note that while bias due to subjectivity may enter the process from professional or citizen contributors this is not to assume, as Wolf (1974, p. 27) cautions, " . . . that value positions lack factuality. "

The dilemma of subjectivity does not apply in such an obstructive way to all evaluative considerations. Some values approach nearly universal appeal or are so widely adhered to that they are safe" evaluative criteria. Examples of such agreed upon values include; health, income, jobs, safety, housing, nourishment, education, recreation, and many other quality of life dimensions (Finsterbusch and Wolf, 1972, p. 314). Yet, while few persons would prefer sickness to health, there is no consensus on exact relative rankings for such commonly held values. Only the direction of these impacts--positive or negative--can be indicated with certainty.

The question remains then, how can SIA arrive at a total quality of life score for alternative policies? The most popular solution to this problem and one thought to be sufficiently democratic is to " . . . ascertain the evaluations by the community and interested parties of the alternative policies" (Finsterbusch and Wolf, 1977, p. 315), though as Wolf (1974, p. 28) observes, "the unpalatable alternative is to restore planner biases as to 'what the people want'," it is also true that "the public does not necessarily choose the 'best' alternative" (Finsterbusch and Wolf, 1977, p. 315). An appropriate concluding note to the issue of subjectivity is the apparent consensus among the majority of authors reviewed in the SIA literature that public involvement would seem to offer the greatest likelihood of 'accuracy and reliability in evaluating social impacts, given the abundance of methodological and technical limitations.

As with assessment procedures, the social research techniques appropriate for impact evaluation are drawn from the entire "arsenal" of the social sciences. Methods used tend to emphasize group theory, value analysis and, decision making. A review of all the techniques available would be impossible here but the following list groups the approaches developed by various researchers, as described by Finsterbusch and Wolf in Methodology of Social Impact Assessment

- identification of affected parties
- evaluations of specific projects by identifying and testing planners assumptions
- intensive workshops to identify public perceptions
- computer based methods of value analysis
- computer based modeling of ground structure and problem solving
- communication analysis and guidance Wolf (1974, p. 28) has summarized the status of impact evaluation in his concurrence with a colleague on the axiomatic relationship of public involvement and social impact assessment; "whatever the difficulties, we must agree with Baur's [1973] assessment, 'an understanding o social effects cannot be made without regard to the kind and extent of public involvement in planning and management of the project'. "

## Conclusion

It is difficult to summarize meaningfully a subject which is made intelligible to the reader only through lengthy description. It may be more useful to link several key ideas which can provide a problem-solution background for the issue of social impact assessment.

The analytic problem of social impact is one of an almost limitless universe of social factors affecting and reaffecting each other, combining and recombining in circumstances which are changed by those very factors themselves and by previous changes. Wolf (Glickfeld, 1973, p. 60) explains this dynamic system state most aptly, saying, "Clearly SIA is speaking the language of causal analysis but it is a situation of complex causality, with many, many relations and interactions between and within category sets.

The practical problem of assessing social impact is essentially one of both concept and technique. Wolf speaks to this point as well, observing that "While SIA has been largely confined 'to specific, site-centered projects, as was environmental impact assessment in its earlier stages, this piecemeal approach is now suspect. A case-by-case treatment may well result in the whole being less than the sum of its parts. Rather, a systemic approach is indicated, in whose context specific projects can be assessed incrementally (even as they are now justified)" (Wolf, 1974, p. 14).

The solutions available for the problem of assessing social impact have been seen to be numerous but often unproven. Often times they are expensive, time consuming, and prohibitively difficult to apply. Despite the pessimistic aspects of the "solutions" that have been described, they have their worth both as means and ends.

Firstly the process of impact assessment, if it is made to be properly pluralistic and democratic, can be a form of what Peterson and Gemmell (1977, p. 384) have termed "educational negotiation. " That is, in the course of their participation people can stimulate modifications of basic questions as well as the conceptualization process while at the same time, they will be educating themselves interactively about the alternatives, the questions and the pieces of the puzzle brought by other members of the group. Through this means the "quality" of the human resource base may be enhanced.

Secondly, whatever its methodological limitations, social impact assessment, if properly acknowledged, can stimulate greater sensitivity on the part of decision-makers. "There is a strong tendency for the managers of any system to improve the performance of the system on these variables that are regularly measured. Even a crude, approximate measure would reinforce the manager s judgment on the importance of what are now known as qualitative' variables" (Wolf, 1974, p. 14).

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# VI . An Impact Assessment Methodology for Sand Dune Mining

Pending development of operational quantitative models of coastal ecosystems and their components, the most practical methodology for assessing possible impacts of a land use activity is a checklist of the components and a matrix depiction of the relationships involved.

The Michigan Sand Dune Protection and Management Act focuses on one use of the dunes, sand mining, and specifies consideration of “aesthetic, environmental, economic, industrial, and agricultural interests in this state. ” Previous sections of this report have detailed the potential impact-causing attributes of sand mining and the basic concepts and criteria for environmental, aesthetic, and socio-economic impact assessment.

Sec. 5 of the Act directs that the impact assessments shall include economic impacts, compatibility of the proposed mining operation with adjacent land uses, and impacts of the mining activity on biological resources, groundwater supply and flow and adjacent surface resources. The methodology one would expect to see adopted by most applicants would be to address each of these items descriptively, based on observations on the site and some qualitative judgment of the degree of probable impact. This report presents the conceptual base for more precise assessment of the aesthetic and socioeconomic interests affected by sand mining and suggests that quantitative measurement is possible. The intent is to develop as complete a checklist as possible for the descriptive portions of an environmental impact assessment. This report also suggests that some (socio-economic) impacts can only be assessed through public response to a specific proposal. Environmental impacts, in the sense of physical-biological components of the environment, are seen to depend on the dynamics of a particular site relative to specific impact causing activities.

The first step in developing an impact assessment methodology is to establish--consistent with the Act--equal emphasis among the three components: physical-biological, aesthetic, and socio-economic. This is difficult because the conceptual base and the appropriate analytical approach for each differ considerably. Field survey techniques for the physical-biological are the most well known and the most easily carried out. Expert judgment may be plausibly substituted where data are lacking. The structural components, characteristics, and evaluative criteria are widely known, with supporting information available from several disciplines, numerous references, and previous impact assessments. Little of this is true of the aesthetic and socio-economic.

Recognizing that description will dominate methodology, and that professional surveys for aesthetic and socio-economic impact analysis are unlikely to be undertaken, we have chosen to extract from the concepts and theory of those analyses the criteria that could be a part of each sand mining impact assessment. Evaluation of those criteria would then take place in three ways: first, by the applicant preparing the impact assessment; second, by the agencies reviewing it; third, by the public as citizens respond to and participate in the review of the impact assessment. Obviously different weights, rankings, priorities will be placed on the criteria by the three parties. There are no a priori weights that can be placed, except in the case of those physical-biological criteria which have a clearly negative effect on the structure or function of a dune system.

Having identified the criteria and organized them as a series of checklists, the next step is to match them with the impact-causing activities outlined in Section I. This operation provides a discipline for preparation of an impact statement by ensuring that each activity is evaluated against the full range of possible impacts--social-economic, e. g. , as well as physical. Each cell in the matrix may be used to indicate relative degrees of impact or relative importances of impact.

This simple device serves both applicant and reviewer by providing a visual summary of the descriptive material in the impact statement. Also, the lists of both impacts and criteria may be expanded to cover new situations or concerns.

Following are the three sets of criteria and where possible, accompanying lists of impacts based on the material in Sections II-VI. The list of aesthetic criteria also includes mitigating measures and an explanatory note. These lists are followed by the matrix with the criteria summarized across the top and the mining activities from Section I listed down the left side.

## Physical and Biological Impact Criteria

### A. Physical Elements

Sand quantity

- physical mass present in a locale

Water quantity -

- mass of water present in given body of water, drainage regime or aquifer

Sand quality

- as measured by amount of organic material present, particle size or pH

Erosion

- splash, sheet, rill or gully erosion causing sand removal Leaching
- movement of water through the sand, clay and soil Mulching
- accumulation of organic matter at or near surface in varying stages of decomposition

Structure

- agglomeration of sand particles Infiltration and permeability
- water entering sand Aerobic conditions
- concentration of oxygen in sand

Sand moisture

- amount of water in soil including hydroscopic, capillary and free water
- Water table -. upper surface of groundwater
- Flood probabilities area,- frequency and land uses affected
- Wind modification removal or addition of windbreak material Temperature modification
- changes in wind pattern and land elevations
- Spatial location of water drainage alteration, wetand fill, borrow pits
- Alteration of active dune processes
- sand supply and transport

### B. Biological Elements

- Total standing crop of organic matter
- dry weight of vegetative material Plant productivity
- enhancement or degradation of vegetative replenishment
- Animal production - enhancement or degradation of animal populations
- Species diversity
- promotion of diversity among various biota
- Proliferation of undesirable biota
- invasion rate
- Localized survival of rare plant and animal species
- species and numbers affected

Carrying capacity

- ability of habitat to accommodate plants and animals

Abandonment

- specie retreats

Wildlife breeding and nesting grounds

- species and numbers affected Endangered and threatened plant and animal species
- species and numbers affected Vegetative recovery rates
- ability of plants to regenerate Migratory came species
- waterfowl , terrestrial species Terrestrial microbial communities
- types and numbers affected Animal corridors
- indigenous routes pathways, territories -of various species Eutrophication
- lake, pond, wetland succession Food web index
- chain of food including herbivores, carnivores and omnivores Nutrient supply
- available foods for terrestrial biota Sensitivity of native plant and animal species
- to pollutants, air and water
- After these physical and biological impact criteria are addressed, the following
- determinations must be made
- 1. What are the nature and extent of physical and biological changes that would constitute significant impact on the ecosystem?
- 2. What criteria can be used to determine whether impacts are significant?
- 3. How can studies be designed and implemented to determine whether impacts are significant?

An additional tool may be used to help delineate the relative impacts of activities associated with sand dune mining. This is a matrix having sand mining activities on one axis and physical and biological impacts on the other axis along with impacts on aesthetics and socio-economic factors. Such a matrix may be found at the end of the report.

## Aesthetic Criteria, Impacts, And Mitigations

Note: Included in Section V (p. 47, 48) are the intangible" parameters upon which a full aesthetic impact element must be based. Because it is beyond the scope of this study to develop all of the visual attribute descriptors into a complex, integrated visual assessment system, a modified list has been included below. More tangible aesthetic criteria, their impacts and mitigating measures have been listed to aid in immediate, practical but rudimentary examination of important aesthetic features pending the formulation and testing of a visual assessment "language" satisfactory to resource managers and citizens alike.

## A. Vegetation Removal Impacts

- damage to remaining vegetation resulting from increased wind, rain, light, snow, and abrasion stress
- increased wind and water erosion
- alteration of view characteristics Criteria
- amount and type to be removed
- amount and type remaining
- size of area to be cleared
- percentage of site to be cleared
- landscape character of surroundings
- potential for natural or induced revegetation during life or cell operation
- potential for revegetation after clearing Mitigation Measures
- no cutting
- selective removal conserving peripheral, no-dig, or critical a re as
- - selective removal of individuals only to the extent necessary to allow access
- selective pruning of vegetation offering only partial obstruction
- transplant removed stock to nursery or buffer areas
- species replacement for vegetation removed; new stock added to nursery to compensate for that destroyed
- establish setback for boundary of cleared area based on distance necessary to prevent stress damage to vegetation marked for conservation, e. g. , drop line might be minimum setback
- supplement remaining vegetation with understory edge plantings, or fast growing sheltering varieties to reduce environmental stress
- establish minimum depths for buffer or vegetation conservation areas based on revegetation criteria

## B. Vegetation Disposal Impacts

- plume from combustion; smoke, heat and vapor
- obstruction or alteration of view characteristics Criteria
- amount and type to be accumulated
- size of area to be employed for disposal
- percentage of. site to be employed for disposal
- landscape character of surroundings
- method of disposal to be used:
- burning -waste heap burial
- chipping for reuse
- volunteer cutting and hauling
- sale for commercial or domestic use Mitigation Measures
- ensure constructive recycling of vegetation waste through commercial or volunteer disposal for reuse or on site reclamation as soil stabilization and nutrient material
- minimize volume of vegetation destroyed through conservation and transplanting procedures

## C. Vegetation Replacement Impacts

- decreased visual intrusion of mining related activities and structures if planting is adequate, and successful
- possibility of increased visual intrusion by dead, dying or unhealthy vegetation if efforts are unsuccessful or inadequate Criteria
- form and size relationships of species to be used - color and texture relationships of species to be used throughout four seasons
- amount and type of vegetation to be established
- size of area to be revegetated
- percentage of site to be revegetated
- landscape character of surrounding landforms, waterbodies and structures
- purpose of planning design(s):
- enclose, screen or otherwise conceal objectionable views stabilize slopes
- reduce noise and filter dust
- recondition soils
- improve visual/aesthetic quality
- prevent or impede access

Mitigation Measures

- establish list of species and circumstances in which they may be recommended for revegetation purposes based on the following:
- planting purpose (above)
- aesthetic criteria (above)
- differential advantages and disadvantages of young and old stock for use in land reclamation
- the following environmental conditions which characterize sand mines and limit species suitable for revegetation;
- + unworkably steep slopes
- + inhibitory water regime
- + compaction and cementation
- + inhibitory surface temperature
- + + wind turbulence, erosion and abrasion
- + + low nutrient status
- + low seed bed quality
- + + absence of soil micro fauna and flora (+ =condition present, + + = condition extreme)
- genetic source of stock

- seasonal advantages arid disadvantages of deciduous coniferous types
- seasons and timing of planting and other pertinent horticultural criteria
- Note: Noise attenuating and dust filtering capacities of vegetation are rather limited. A clear understanding of their true potential is critical.
- establish model landscape techniques which may be employed to integrate the above species characteristics with land forms, microclimate, and structural demands and opportunities
- establish recommended procedures for vegetation maintenance including;
- fertilization/soil amendments "weed" suppression
- mowing, pruning or grazing vandalism and trespass prevention
- establish nursery and other vegetation establishment measures as the first phase of mine operations following plan approval
- encourage integration of all vegetation establishment measures with plans for end use thus deriving optimal value from most mature vegetation
- encourage interim vegetation uses so long as they are consistent with and contribute to approved end use, e. g. , christmas tree farming conducted with selective removal to yield a partially prelandscaped site

### D. Site and Structural Design Impacts

- damage to vegetation from substances and actions associated with development and structural operations
- maximized or minimized complementarily of vegetation and structures (see vegetation removal

Criteria

- amount and type of proposed development
- size of area to be developed
- percentage of site to be developed
- landscape character of surroundings
- species composition of adjacent plant communities and relative hardiness

Mitigating Measures

- employ earth integrated architecture where possible using earthen cover to effect an appearance similar to the
- surroundings

reduce height of buildings to minimize "aerial" intrusion

- excavate for deep foundations to allow tall structures to be set further into the ground, thus reducing apparent height
- use surface colorants (paints) to blend appearance of structure with the predominant background, e. g. ; predominantly vegetated backgrounds may require green tones, aerial portions of tall structures may require light blue tones to blend with the sky, and mineral pit backgrounds may call for brown structural tones
- establish earthen or vegetation screens (or combinations) to fully or partially conceal structural intrusions
- dc-emphasize appearance of obtrusive height and clutter by standardizing pitch of rooflines
- do-emphasize appearance of obtrusive clutter by standardizing pitch or otherwise avoiding the "scissors effect' in which opposing conveyors appear to cross
- cluster structural units near or within vertical elements of the landscape to reduce visual intrusion and need for additional screening
- organize clustered structural areas according to a grid-type ground pattern to reduce apparent confusion

### E. Pit and Excavation Activities Impacts

-. displacement of plants, animals, and soil

- removal or recontour of land forms Criteria
- location and volume of proposed extraction
- surface area •to be affected
- percentage of site to be excavated
- landscape character of surroundings Mitigating Measures
- employ directional or sequential pit working techniques; working across instead of along predominant sight lines, thus reducing period of intrusion
- reduce visual access to objectionable views by curving access roads, utility corridors, etc.
- stockpile overburden in the form of earthen barriers to screen or enhance objectionable views

## Socio-Economic Impacts

### A. Displacement and removal of residents

Economic impacts on displacees

New housing costs and their compensation: net worth, rent, maintenance, utilities and fuel

Mortgage: ability to obtain, interest rates, size of payments

Moving expenses and their compensation

Changes in transportation costs

Social and psychological impacts on persons displaced

Anxious anticipation and uncertainty

Search time and inconvenience -

Disrupted social relationships

Displacement from familiar (and positively valued) surroundings

End of a set of habitual behaviors

Quality of the relationship with housing relocation personnel Housing changes for persons displaced

Renter to owner and owner to renter

Type of housing

Qualitative comparisons of before and after housing Impact of residential displacement on the neighborhood

Loss of customers, members, and constituents for businesses, schools, churches, and services

Increased distance to displaced friends and relatives

Deterioration of condemned property and reduced neighborhood attractiveness

Tighter housing market, higher prices, possible overcrowding

## B. Acquisition of non-residential properties

Displacement of non-residential properties

Difficulty of obtaining suitable relocation sites: search time, financing, compensation

Moving expenses: compensation, inconvenience

Costs of relocation: lost customers, promotional costs, turnover, new layout and routines, etc.

Marginal neighborhood oriented businesses liquidated Removal of resources

Loss or degradation of parks, farms, woods, open space, and recreational facilities

Loss or degradation of archelogic or historic sites

Increased distance, generally, to relocated schools, churches, libraries, etc.

Loss of nearby stores, restaurants, bars, service stations, banks, laundries, etc.

Increased distance, generally, to relocated doctors, dentists, beauticians, barbers, repairman and services

Displacement of places of employment

Increased transportation costs and fuel consumption for contouring

Increased commuting time

Loss of jobs in liquidated businesses

Change of jobs to avoid a longer commute

## C. Proximity effects

Effects on habitat

Highway noise, vibrations, and interference with media reception

Damage from construction vibrations

Air pollution

Water pollution

Spoiled view

Externalities borne by proximate properties

Insulation and soundproofing

Air conditioning

Fencing, shrubs, landscaping

Increased maintenance and housework - especially cleaning and painting

Effects on residents

Safety of pedestrians, bikers, and motorists

Construction inconveniences: detours, traffic disruption, dirt, dust, run off, noise, truck traffic in area, etc.

Possible construction business or employment (mainly benefit outsiders)

Effects on businesses, services, Schools, churches, hospitals Changed visibility to the public and accessibility Increased noise and air pollution

Aesthetic effects

Decreased business or services because of construction inconveniences

Highway oriented businesses on previous major routes have declining business

## D. Accessibility effects

Invasion of outsiders ho:

Crowd shops, services, businesses, parking, roads, parks, etc.

Compete- for jobs, recreation facilities, and dates

May cause crime and vandalism

## E. Darner effects

Pedestrian deprivation

Neighborhood isolation

Neighborhood division

Hindrance to emergency services

## F. Additional impacts on the neighborhood

Changes in land values and use

Zoning changes - population and land use changes - changes the character of the neighborhood

Reduced property values because of proximity effects New traffic patterns and their effects

Market, service, membership and constituent areas change

Neighborhood boundaries change

The geography of social networks changes

Increased traffic density near interchanges

Community characteristics which may chance

Degree of integration versus conflict

Residential stability and tenure

Population distribution and densities

Community plans and goals

Plans and goals of private interests

Population characteristics

Effects on tax revenues and expenditure; (short. term/long term, increase/decline)

Effects on mass transit systems and ridership

Political participation (usually in opposition to project) Time costs

Social benefits from interaction and cooperative action with other participants

Government responsiveness and attitudes toward government

### G. Pre-acquisition changes

Reduced value and marketability of properties in the proposed mining area that might be displaced

Reduced maintenance and improvements - deterioration - reduced neighborhood attractiveness

Increased motivation for residents to move out of the area

Real estate speculation

Formation of neighborhood associations to oppose or support certain alignments

Political influence by interested parties

## Socio-Economic Impact Criteria

### A. Demography

Population size of the community

Number of inhabitants (+ = positive relationship up to 500,000; negative above that )

Amount of population growth in the community

Annual amount of growth through natural increase during the past 10 years (+ = cannot be specified at the present time)

Annual amount of growth through net migration during the past 0 years (+ = cannot be specified at the present time)

Rate of population growth in the community

Annual percentage rate of growth during the past 10 years (+ = the closer to 1%)

Degree of urbanization of the county

Proportion of population in cities of 20,000 or more (+ = the closer to 60-75%)

Population density of the county

Number of persons per square mile !+ = the closer to 100)

Population density in SMSA

Population concentration of the county

Proportion of the total population in the largest urban place (+- the closer to 20-50%)

Ace dependency in the community

Proportion of the population under' 13 and over £5 (+ = the smaller the proportion

Sex ratio of the community

Ratio of males to females (+ = closer to 1. 0)

Ethnic composition of the community

Percent of the population nonwhite (± the closer to 13%)

Family size in the community

number of persons per household (4 = the closer to 2. 0)

Number of 1-person households

E3. Economy

Job opportunities

Proportion of available unskilled jobs that are vacant (-- higher proportion

Proportion of available semi-skilled jobs that are vacant higher proportion)

Proportion of available skilled jobs that are vacant (+ = higher proportion)

Proportion of available clerical/sales jobs that are vacant higher proportion)

Proportion of available managerial jobs that are vacant (+ higher proportion)

Proportion of available professional jobs that are vacant =higher proportion)

Job distribution

Proportion of available jobs that are unskilled (+ = lower proportion) Proportion of available jobs that are semiskilled (+ = lower proportion)

Proportion of available jobs that are skilled (+ = higher proportion)

Proportion of available jobs that are clerical/sales (+ = lower proportion)

Proportion of available jobs that are managerial (+ = higher proportion)

Proportion of available jobs that are professional (+ = higher proportion)

Gross county product size

Gross county income per year (+ = greater amount)

Gross county product growth

Annual percentage rate of growth in gross county income during past 10 years (4 = higher rate)

Value added per worker in manufacturing ($1,OO0)

Value of construction per worker ($1,000)

Sales per employee in retail trade ($1 ,000)

Sales per employee in wholesale trade ($1,000)

Sales per employee in selected services ($1,000)

Employment level

Proportion of the labor force that is employed (+ = greater the proportion)

Participation in the labor force

Proportion of workers in the labor force (+ = greater the proportion)

Proportion of persons age 65 or older in the labor force (± = greater the proportion)

Percent working outside county of residence

Property tax base

Total value of assessed real property (+ = higher amount)

Total value of assessed personal property (+ = higher amount) Financial inflow from, federal government.

Amount of federal revenue sharing funds received per year (+ = greater amount)

Amount of direct federal aid to impacted areas received per year =greater amount)

Amount of other federal monies received per year (+ = greater amount)

Price level

Consumer price index for the community (+ = lower the index) Cost of living index

Public revenues

Total revenues collected by all community governmental units in past year (+ = greater amount)

Local government revenue per capita

Percent of revenue from Federal Government

Commercial facilities

Number of banks and savings and loan associations per 1,000 population

Number of retail trade establishments per 1,000 population

Number of selected service establishments per 1,000 population

Wealth

Total bank deposits per capita

Savings per capita

Ratio of total property income to total personal income

Percent of owner-occupied housing units

Percent of households with one or more automobiles

Median value owner-occupied, single family housing units

## B. Social Structure

Educational attainment

Median educational attainment of persons age 25 or older (4 = higher attainment)

Socioeconomic status

Mean occupational status of the work force (+ high status)

Median gross family income (+ = high income)

Mean income per family member Housing availability

Number of unoccupied dwelling units per 1000 population =greater number) Housing space

Mean dwelling unit size (sq. ft. ) per person = greater space) Proportion of dwelling units that are single-family detached =high proportion)

Residential stability

Mean length of occupancy of all dwelling units (+ =

length)

Proportion of all dwelling units that are owner occupied higher proportion)

Mass media coverage

Combined circulation per capita of all local newspapers (÷ high circulation)

Number of television channels in the area = ‘greater number)

Percent of occupied housing units with T’! available

Local radio stations per 1,000 population

Civic association extensiveness (e. g. business, professional fraternal, service, educational, ethnic, and political associations) Number of associations per 1000 population (÷ = greater number)

Civic association participation

Total memberships per capita in all such associations (+ = higher number)

Political participation

Proportion of eligible persons who are registered (+ = higher proportion)

Turnout rate in local elections during previous year (+ higher rate)

Local government size

Total number of community governmental employees per 1,000 population (+ higher number)

Total program budget of all community governmental units per capita =greater amount)

Mobility

Motor vehicle registrations per 1,000 population

Motorcycle registrations per 1,000 population

Percent of households with one or more automobiles

## C. Public Services

Public education

Mean class size (students per classroom) (+ = low number)

Mean student-teacher ratio (+ = low ratio)

Mean educational level of teachers (+ = high level)

Total educational expenditures per student per year (+ = greater amount)

Median school years completed by persons 25 years and over

Percent of persons 25 years and over, who completed 4 years of high school or more

Percent of males ages 16 to 21 who are not high school graduates

Percent of population ages 3 to 34 enrolled in schools

Percent of population age 16-64 with less than 15 years of school but with vocational training

Percent of persons 25 years and over who completed 4 years of college or more

Percentage of male enrollment

Percentage of female enrollment

Medical care

Hospital occupancy rates

Per capita local government expenditures on health

Hospital beds per 1000 population (+ greater number)

Total hospital expenditures per capita per year (+ = greater amount)

Number of mental health clinics per 1000 population (+ = greater number)

Number of physicians per 1000 population (+ = greater number)

Number of dentists per 1000 population (+ greater number)

Number of psychiatrists and clinical psychologists per 1,000 population (+ = greater number)

Public health

Total local governmental expenditures on public health per capita per year (+ = greater amount)

Number of public health workers (excluding sanitation) per 1000 population (+ = greater number)

Number of sanitation employees per 1000 population (+ = greater number)

Tons of solid waste generated by manufacturing per million dollars value added

Fire protection

Number of fire employees per 1000 population (+ = greater number)

Total local government expenditures on fire protection per capita to =greater amount)

Fire protection classification of the community (+ = higher the classification)

Police protection

Number of police employees per 1000 population (+ = greater number)

Total local government expenditures on police protection per capita =higher proportion)

Proportion of all cases cleared by arrest (+ = higher proportion) Public transportation

total expenditures for public transportation of all kinds per capita per year (+ = greater amount)

Number of miles of scheduled bus routes per capita (+ greater number)

Number of buses per capita (+ = greater number)

Total expenditures for street maintenance per capita per year =greater amount)

Percent of workers who use public transportation to work Telephone Service

Percent of occupied housing units with a telephone available Legal services

Number of attorneys per 1000 population (+ = greater number) Total budgets of legal services centers per capita (+ = greater amount)

Median months to trial i. criminal cases (+ lower number Median months to trial in civil cases = lower number)

Quality of text of the report past this point is not readable.

| MINING ACTIVITIES ↓ | ENVIRONMENTAL → PARAMETERS → | Vegetation | Habitat | Species Composition | Species Diversity | Carrying Capacity | Endangered Species | Land Forms | Topography | Shoreline Forms | Water Forms | Vegetation Forms | Land Use | Man-Made Structures | Demography | Economy | Social Structure | Public Services | Social Well-Being | Collective Responses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE DESIGN | Mining Actions and Installations | | | | | | | | | | | | | | | | | | | |
| | Processing Plant | | | | | | | | | | | | | | | | | | | |
| | Accessory Buildings | | | | | | | | | | | | | | | | | | | |
| | Antennas, Towers, Stacks and Conveyor Belts | | | | | | | | | | | | | | | | | | | |
| | Parking Lots and Paved Surfaces | | | | | | | | | | | | | | | | | | | |
| | Open Storage | | | | | | | | | | | | | | | | | | | |
| | Closed Storage | | | | | | | | | | | | | | | | | | | |
| | Conveyors and Pipe Lines | | | | | | | | | | | | | | | | | | | |
| | Barge Transport Facilities | | | | | | | | | | | | | | | | | | | |
| | Rail Transport Facilities - | | | | | | | | | | | | | | | | | | | |
| | Truck Transport Facilities | | | | | | | | | | | | | | | | | | | |
| | Road Ways | | | | | | | | | | | | | | | | | | | |
| | Utility Lines and Corridors | | | | | | | | | | | | | | | | | | | |
| | Fencing and Other Boundary Enclosures | | | | | | | | | | | | | | | | | | | |
| | Lighting Systems Sound (P. A. ) Systems | | | | | | | | | | | | | | | | | | | |
| PREP/CONST | Clearing | | | | | | | | | | | | | | | | | | | |
| | Stripping | | | | | | | | | | | | | | | | | | | |
| | Dredging | | | | | | | | | | | | | | | | | | | |
| | Excavating | | | | | | | | | | | | | | | | | | | |
| | Filling | | | | | | | | | | | | | | | | | | | |
| | Transport Of Equipment & Materials | | | | | | | | | | | | | | | | | | | |
| | Erection of Plant S Accessory Structures | | | | | | | | | | | | | | | | | | | |
| | Installation of Utilities | | | | | | | | | | | | | | | | | | | |

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| MINING ACTIVITIES ↓ | **ENVIRONMENTAL PARAMETERS → PARAMETERS →** | Vegetation | Habitat | Species Composition | Species Diversity | Carrying Capacity | Endangered Species | Land Forms | Topography | Shoreline Forms | Water Forms | Vegetation Forms | Land Use | Man-Made Structures | Demography | Economy | Social Structure | Public Services | Social Well-Being | Collective Responses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPERATIONS | Disposal | | | | | | | | | | | | | | | | | | | |
| | Transplanting | | | | | | | | | | | | | | | | | | | |
| | Overburden Stockpile | | | | | | | | | | | | | | | | | | | |
| | Waste Sand | | | | | | | | | | | | | | | | | | | |
| | Fines and Contaminant Dump | | | | | | | | | | | | | | | | | | | |
| | Mobile And Stationary Equipment | | | | | | | | | | | | | | | | | | | |
| | Dredge | | | | | | | | | | | | | | | | | | | |
| | Pit | | | | | | | | | | | | | | | | | | | |
| | Washing | | | | | | | | | | | | | | | | | | | |
| | Drying | | | | | | | | | | | | | | | | | | | |
| | Classifying | | | | | | | | | | | | | | | | | | | |
| | Barge Transport | | | | | | | | | | | | | | | | | | | |
| | Rail Transport | | | | | | | | | | | | | | | | | | | |
| | Truck Transport | | | | | | | | | | | | | | | | | | | |
| | Nursery | | | | | | | | | | | | | | | | | | | |
| | Buffer Planting | | | | | | | | | | | | | | | | | | | |
| | Regrading | | | | | | | | | | | | | | | | | | | |
| | Soil Restoration | | | | | | | | | | | | | | | | | | | |
| | Revegetation | | | | | | | | | | | | | | | | | | | |
| END | Land Use | | | | | | | | | | | | | | | | | | | |
| | Site Plan | | | | | | | | | | | | | | | | | | | |
| | Abandonment | | | | | | | | | | | | | | | | | | | |